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29 June 2009
File No. 36067-001

Ms. Alana Lee
Project Manager
U.S. Environmental Protection Agency Region 9
Superfund Division SFD-7-3
75 Hawthorne Street
San Francisco, CA

Subject: Submittal of Final Supplemental Feasibility Study for the Vapor Intrusion Pathway, Middlefield-Ellis-Whisman Study Area, Mountain View and Moffett Field, California

Dear Alana:

Please find enclosed the Final Supplemental Feasibility Study for the Vapor Intrusion Pathway, Middlefield-Ellis-Whisman Study Area, Mountain View and Moffett Field, California.

If you have questions regarding this document, please feel free to call.

Sincerely yours,
HALEY & ALDRICH, INC.

Elie H. Haddad, P.E.
Vice President

Enclosure

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FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR
VAPOR INTRUSION PATHWAY
MIDDLEFIELD-ELLIS-WHISMAN STUDY AREA
MOUNTAIN VIEW AND MOFFETT FIELD, CALIFORNIA

by

Haley & Aldrich, Inc.
San Jose, California

Locus Technologies
Mountain View, California

for

Fairchild Semiconductor Corporation
Intel Corporation
National Aeronautics and Space Administration (NASA)
NEC Electronics America, Inc.
Raytheon Company
Schlumberger Technology Corporation
SMI Holding LLC
SUMCO USA Corporation
Vishay GSI, Inc.

File No. 36067-001
June 2009

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	**Description**
106 Order	Administrative Order for Remedial Design and Remedial Action
AE	Air Exchange
ARARs	Applicable or Relevant and Appropriate Requirements
BAAQMD	Bay Area Air Quality Management District
Cal/EPA	California Environmental Protection Agency
CARB	California Air Resources Board
cfm	Cubic feet per minute
CEC	California Energy Commission
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQA	California Environmental Quality Act
COCs	Chemicals of Concern
CSF	Cancer Slope Factor
1,1-DCA	1,1-Dichloroethane
1,2-DCA	1,2-Dichloroethane
1,2-DCB	1,2-Dichlorobenzene
1,1-DCE	1,1-Dichloroethene
1,2-DCE	1,2-Dichloroethene
EA	Endangerment Assessment
EPA	U.S. Environmental Protection Agency
Fairchild	Fairchild Semiconductor Corporation
Freon 113	Trichlorotrifluoroethane
FS	Feasibility Study
HDPE	High Density Polyethylene
HQ	Hazard Quotient
HVAC	Heating, Ventilation and Air Conditioning
ICIP	Institutional Controls Implementation Plan
IDF	Intermediate Distribution Frame
Intel	Intel Corporation

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Description
IRIS	Integrated Risk Information System
LLDPE	Linear Low Density Polyethylene
MCL	Maximum Contaminant Level
MEW	Middlefield-Ellis-Whisman
mg/kg	milligram per kilogram
$\mu g/m^3$	microgram per cubic meter
µg/L	microgram per liter
NAS	U.S. Naval Air Station
NASA	National Aeronautics and Space Administration
Navy	U.S. Department of the Navy
NEC	NEC Electronics America, Inc.
NRC	National Research Council
NRP	NASA Research Park
OAQPS	EPA Office of Air Quality Planning and Standards
OEHHA	Office of Environmental Health Hazard Assessment
O&M	Operations and Maintenance
OSWER	EPA Office of Solid Waste and Emergency Response
PCE	Tetrachloroethene or perchloroethene
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
PVC	Polyvinyl Chloride
RAO	Remedial Action Objective
Raytheon	Raytheon Company
RI	Remedial Investigation
ROD	Record of Decision
SMI	SMI Holding LLC
SSD	Sub-slab Depressurization
SSP	Sub-slab Pressurization
SUMCO	SUMCO USA Corporation

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	**Description**
SVE	Soil Vapor Extraction
TBC	To Be Considered
1,1,1-TCA	1,1,1-Trichloroethane
TCE	Trichloroethene
VI	Vapor Intrusion
Vishay	Vishay GSI, Inc.
VOCs	Volatile Organic Compounds
WATS	West-Side Aquifers Treatment System

GLOSSARY

Name	Definition
Air Exchange Rate	Air Exchange (AE) Rate is the rate at which outside air replaces indoor air in a space. For example and AE rate of 1/hr means that outside air replaces the indoor in a space once each hour.
Background (Outdoor Air)	Background (Outdoor Air) in the context of indoor air/vapor intrusion refers to the presence of chemicals due to sources other than volatilization from the subsurface. Examples of background sources may include local industrial sources and more distant sources.
Background (Indoor Air)	Background (Indoor Air) in the context of indoor air/vapor intrusion refers to the presence of a chemical in indoor air that is contributed by a source other than vapor intrusion. Background for indoor air could be the result of indoor sources (consumer products) and/or outdoor sources (local industry, volatilization from the subsurface, and more distant sources).
Baseline Building	A Baseline Building is a building where no vapor intrusion mitigation activities (e.g., sealing conduits/potential pathways, HVAC system improvements etc.) have been implemented prior to indoor air sampling.
Baseline Condition	Baseline Condition is the status of a building prior to implementation of any vapor intrusion mitigation activities (including sealing conduits/potential pathways and HVAC system improvements, etc.)
Exhaust Air	Exhaust air is air that is removed from a space that is discharged to the outside.
Action Level	The Action Level is the indoor air contaminant concentration whereby vapor intrusion mitigations measures are required to reduce the concentrations. The Action Level for TCE in indoor air at the MEW Site is 1 $\mu g/m^3$ of TCE in air for residential buildings and 5 $\mu g/m^3$ of TCE in air for commercial/non-residential buildings.
MEW Area	The area around **M**iddlefield Road, **E**llis Street, **W**hisman Road, and U.S. Highway 101 in Mountain View, California.
MEW Companies	Fairchild Semiconductor Corporation (Fairchild); Schlumberger Technology Corporation (Schlumberger); NEC Electronics America, Inc. (NEC); SMI Holding LLC (SMI); SUMCO USA Corporation (SUMCO, formerly Siltec Corporation); Vishay GSI, Inc. (Vishay, formerly General Instrument Corporation); Intel Corporation (Intel); and Raytheon Company (Raytheon)
Outdoor Makeup Air	Outdoor makeup air is the outdoor air supplied into the building to replace exhaust air.
Preliminary Remediation Goals (PRGs)	PRGs are preliminary cleanup goals for individual chemicals given a specific medium (soil, water, air) and land use (residential, commercial) at CERCLA sites. PRGs are used for site "screening" to help identify areas, contaminants, and conditions that do

GLOSSARY

Name	Definition
	not require further federal attention at a particular site. PRGs are not de facto cleanup standards and should not be applied as such.
Site	Middlefield-Ellis-Whisman (MEW) Study Area in Mountain View, California, and a portion of the former U.S. Naval Air Station (NAS) Moffett Field.
Vapor Intrusion Study Area	The area over the estimated 5 µg/L TCE concentration in the shallow groundwater plume plus 100 foot buffer zone.

FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR THE VAPOR INTRUSION PATHWAY
MIDDLEFIELD-ELLIS-WHISMAN STUDY AREA
MOUNTAIN VIEW AND MOFFETT FIELD, CALIFORNIA

1. INTRODUCTION

This Final Supplemental Feasibility Study (FS) presents an evaluation of a range of remedial alternatives that can be used to mitigate potential vapor intrusion into current and future buildings overlying the shallow volatile organic compound (VOC) plume at the Middlefield-Ellis-Whisman (MEW) Study Area in Mountain View, California and a portion of the former U.S. Naval Air Station (NAS) Moffett Field. The Vapor Intrusion Study Area is defined as the area over the estimated 5 microgram per liter (µg/L) trichloroethene (TCE) concentration in the shallow groundwater plume plus 100 foot buffer zone. This Supplemental FS report was prepared in response to the U.S. Environmental Protection Agency's (EPA's) 8 March 2006 request for a Supplemental Remedial Investigation/Feasibility Study (RI/FS) to address the vapor intrusion pathway in accordance with EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (the Comprehensive Environmental Response, Compensation, and Liability Act) (EPA 1988). The Final Supplemental FS incorporates EPA comments on the Draft Supplemental FS that was submitted to EPA on 16 October 2006 (Locus 2006c). Responses to EPA comments on the Draft Supplemental FS can be found in Appendix A.

In the 8 March 2006 letter to the MEW Companies and the U.S. Department of the Navy (Navy), EPA stated that additional response actions are necessary to address the vapor intrusion pathway at the Site, and requested a Supplemental RI/FS Work Plan and report to address the vapor intrusion pathway into current and future buildings overlying the shallow VOC groundwater plume. The data collected to date indicate that there is no immediate or short-term health risk from the vapor intrusion pathway, but EPA has determined it is appropriate to amend the 1989 Record of Decision (ROD) to ensure the protectiveness of the remedy by addressing the potential for long-term exposure to VOCs through the vapor intrusion pathway.

This Supplemental FS was prepared on behalf of the following entities:

- Fairchild Semiconductor Corporation (Fairchild); Schlumberger Technology Corporation; NEC Electronics, Inc. (NEC); SMI Holding LLC (SMI); SUMCO USA Corporation (SUMCO, formerly Siltec Corporation); and Vishay GSI, Inc. (Vishay, formerly General Instrument Corporation) all of which were named Respondents in the Administrative Order for Remedial Design and Remedial Action, EPA Docket No. 91-4, (106 Order) issued by the EPA (EPA 1990a);

- Intel Corporation (Intel) and Raytheon Company (Raytheon), which entered into the MEW Consent Decree with the EPA (U.S. District Court Case No. C9120275JW); and

- The National Aeronautics and Space Administration (NASA).

The companies listed in subparagraphs 1 and 2 above are generally referred to as the MEW Companies.

The Navy has chosen to not participate in the Supplemental RI/FS process. It is not known how the Navy plans to evaluate vapor intrusion in buildings overlying groundwater with VOCs on Moffett Field for which the Navy has responsibility.

The MEW Companies and NASA submitted a Supplemental RI/FS Work Plan to EPA on 12 May 2006 (Locus 2006a), and EPA provided comments on 16 June 2006. The Supplemental RI and FS reports were prepared in August and October 2006, respectively, in accordance with that work plan and EPA's comments. EPA provided comments on the Supplemental RI and FS in November 2007. The MEW Companies submitted revised reports in January/February 2008. EPA provided comments to the MEW Companies and discussed changes to the FS in 2008 and 2009. This Final Supplemental FS report and the accompanying Final Supplemental RI report (Haley & Aldrich et al, 2009) incorporate final changes made by EPA.

1.1. Reasons for a Supplemental Feasibility Study

A baseline human health risk assessment for the Site was conducted in the 1980s, culminating in the issuance of the 1988 "Endangerment Assessment for the Middlefield-Ellis-Whisman Site in Mountain View, California" (EA; ICF 1988). For those exposure pathways that were quantitatively evaluated in the EA, the exposure assumptions that were used are considered both conservative and reasonable in evaluating risk. The EA focused on the potential for future exposure to Site VOCs if the groundwater and VOC sources were left untreated, and if that water was used for domestic purposes (e.g., drinking, showering, washing). If those pathways were complete, exposure to VOCs through these pathways would be the most appreciable contribution of risk to human health.

Although groundwater at the Site is not currently used for drinking or other use, cleanup actions are being taken at the Site to restore groundwater quality. Because the chemicals at the Site are primarily in the groundwater, the EA concluded that potential exposure to Site chemicals through the inhalation pathway presented negligible risks. Therefore, no Remedial Action Objectives (RAOs) for mitigating the subsurface vapor intrusion pathway were identified.

The understanding of the fate and transport of chemicals in the subsurface to the ambient air has evolved since 1988. Under certain conditions, VOCs in the subsurface can emit vapors that migrate upward through subsurface soils and enter overlying buildings through cracks in floors or through piping conduits or other preferential pathways. In November 2002, EPA's Office of Solid Waste and Emergency Response released an external review draft "Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils" that focuses specifically on this pathway. EPA identified the Site as one requiring further evaluation of the potential for vapor intrusion into indoor air.

In an 8 March 2006 letter, EPA indicated that additional response activities are necessary to address the vapor intrusion pathway from the commingled contaminated shallow groundwater at the Site (EPA, 2006). In the letter, EPA requested the development of a Supplemental RI/FS Work Plan and Report to address the vapor intrusion exposure pathway into current and future buildings overlying the shallow groundwater contamination. All of the air data collected to date indicates that there is no immediate or short-term health concern from the vapor intrusion pathway; however, EPA concluded that there is a potential for concern due to long-term exposure to TCE through this pathway. Therefore, EPA has determined that it is necessary to amend the 1989 ROD to ensure the protectiveness of the remedy by addressing the potential for long-term exposure to VOCs at unacceptable levels through the vapor intrusion pathway. The FS is intended to identify and evaluate a range of alternatives to require that VOCs in indoor air from the subsurface do not exceed EPA's long-term exposure goals.

Extensive investigations have been performed at the Site to evaluate the vapor intrusion pathway into buildings in accordance with work plans previously approved by EPA (Locus 2003; GeoSyntec 2003; MACTEC 2003a&b, 2004; Navy 2003a). The Supplemental RI report (Locus 2006b) compiled the results from the vapor intrusion investigations performed by the MEW Companies, Navy, NASA and EPA for 47 commercial and 31 residential buildings and provided a comprehensive evaluation of conditions under which vapor intrusion may result in indoor air concentrations exceeding long-term exposure goals. The report also evaluated interim mitigation measures implemented to date and discussed findings relevant to developing a Supplemental FS. The Supplemental RI concluded that most sampled buildings at the Site did not exceed long-term indoor air quality goals and that vapor intrusion resulted in indoor air concentrations exceeding long-term exposure goals at the Site where i) commercial building HVAC systems did not provide sufficient outside air exchange rate [defined as the rate at which the indoor air is exchanged with outdoor air] in all or part of the building, ii) the building had a basement or an earthen cellar, or iii) utilities provided a preferential pathway into the building enclosure. In addition, as demonstrated in one particular case, there is a potential for vapor intrusion if an HVAC system is designed to supply air through a sub-floor panel that creates a zone of negative pressure underneath the raised floor, inducing VOC migration from the subsurface, and pulling the VOCs from the sub-floor panel into the building.

The Supplemental FS Report uses the information and findings of the Supplemental RI to evaluate alternatives to address the long-term management and mitigation of potential vapor intrusion into current and future buildings at the Site.

1.2. Site Background

The Site is located in the City of Mountain View, in Santa Clara County, California and on a portion of former NAS Moffett Field (Figure 1-1). Previous investigations at the Site have yielded sufficient information to design and implement extensive soil and groundwater remediation activities by the MEW Companies, the Navy, and NASA. These remedial actions included separate soil and groundwater source control measures and the joint Regional Groundwater Remediation Program. These actions were performed consistent with the EPA-issued ROD (EPA 1989) and subsequent Explanations of Significant Differences (EPA 1990b, 1996) and EPA-approved design and operation reports.

The area around Middlefield Road, Ellis Street, Whisman Road, and U.S. Highway 101 in Mountain View (MEW Area) includes locations of several current and former semiconductor and other manufacturing and industrial facilities. Until 1959, the area south of U.S. Highway 101 was used for agricultural purposes, at which time the area began to be commercially developed with light-industrial facilities. Operations in this area have included semiconductor and electronics manufacturing, metal finishing, and other activities that used chemicals. While in operation, these facilities required the storage, handling, and use of a variety of chemicals, particularly solvents and other compounds in manufacturing processes. Some of the chemicals leaked or were otherwise released to the ground.

Since the 1990s, major redevelopment and reuse has occurred in the MEW Area. Several structures were demolished, and new tenants now occupy new office complexes. These new Site occupants were not operating at the time of the historical chemical releases to the environment and are not currently involved with the investigation and cleanup activities in the MEW Area. During the redevelopment process, addresses of some former properties changed. Table 1-1 shows the former and current MEW property addresses, and Figure 1-2 provides a building outline of the MEW Area. The MEW Area is currently zoned primarily for commercial and light industrial use, and the City of Mountain View has indicated that it has no current plans to change the zoning in the MEW Area. A small area at the western plume boundary of the MEW Area is zoned residential. The MEW Area is not located in an environmentally sensitive area (EPA 2004).

Table 1-1: Former and Current MEW Property Addresses

MEW Company	Former Facility Address	Current Address
Fairchild Semiconductor Corp.	369/441 North Whisman Road (Building 19/ Buildings 13 and 23)	369/379/389/399 North Whisman Road
	515/545 North Whisman Road (Buildings 1 and 2)	515/545 North Whisman Road
	313 Fairchild Drive (Buildings 3 and 4)	313/323 Fairchild Drive
	464 Ellis Street (Building 20)	464/466/468 Ellis Street
	401 National Avenue (Building 9)	401 National Avenue
	644 National Avenue (Building 18)	644 National Avenue
Intel Corporation	365 E. Middlefield Road (Lots 3 and 4)	355/365 E. Middlefield Road 401 E. Middlefield Road
NEC Electronics	501 Ellis Street	501 Ellis Street
Raytheon Company	350 Ellis Street	350/370/380 Ellis Street
	415 E. Middlefield Road (Lots 4 and 5)	401/415 E. Middlefield Road
SMI Holding LLC	455/485 E. Middlefield Road	455/487 E. Middlefield Road
Vishay/SUMCO	405 National Avenue	425 National Avenue

Moffett Field is located to the north of the MEW Area just north of U.S. Highway 101. NAS Moffett Field was commissioned in 1933, and the NASA facility opened there in 1940 as a laboratory of the National Advisory Committee on Aeronautics. The Navy operated continuously at NAS Moffett Field until it transferred most of the facility (with the exception of Navy housing in the Orion Park and Wescoat Housing areas) to NASA in July 1994 (EKI 2001). The Navy is responsible under a Federal Facility Agreement with EPA and the State of California to investigate and clean up releases on Moffett Field. NASA conducts its ongoing environmental activities pursuant to a Memorandum of Understanding between the Navy and NASA (Navy and NASA 1992). Current uses of the area north of U.S. Highway 101 overlying portions of the regional groundwater VOC plume include: military housing (Wescoat Housing), Hangar One, air operations, administrative offices, various storage buildings, and historic structures. Land use is described in the NASA Ames Development Plan (NASA 1994). There are no current plans to change ownership (EKI 2001).

The regional groundwater VOC plume is located beneath portions of NASA Ames Research Center and NASA Research Park (NRP). Future land use in this area of Moffett Field is described in NASA's Final Programmatic Environmental Impact Statement (NASA 2002). New educational, office, research and development, museum, conference center, housing, and retail spaces are planned for the NRP. Plans also include the demolition of non-historic structures. Residential development is tentatively planned for areas over the regional plume in the NRP.

1.3. Report Organization

This Supplemental FS was prepared using EPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA 1988). Chapter 2 summarizes the results and findings of the Supplemental RI for the Vapor Intrusion Pathway performed at the Site. Chapter 3 presents a discussion of the interim mitigation measures that have been implemented at the Site to address the vapor intrusion pathway. Applicable or Relevant and Appropriate Requirements (ARARs) are discussed in Chapter 4, and Chapter 5 presents Action Levels for short-term and long-term exposure for indoor air. Chapter 6 includes identification and initial screening of remedial technologies. Chapter 7 develops remedial alternatives for the vapor intrusion pathway and provides detailed analyses of each alternative. Chapter 8 presents analyses of institutional controls. Finally, Chapter 9 lists the recommended remedial alternatives and provides a general approach for implementation of these alternatives.

2. SUMMARY OF SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT

The Supplemental RI report presented the results of the investigation of the potential vapor intrusion pathway into buildings overlying the shallow VOC plume at the Site. Extensive remedial investigations have been performed at the Site to evaluate the vapor intrusion pathway. The Supplemental RI report compiled the results from the investigations performed by the MEW Companies, Navy, and NASA, provided a comprehensive discussion of the interim mitigation measures implemented to date, and discussed findings based on the large dataset accumulated during this Supplemental RI process. Findings from the Supplemental RI support the development of this Supplemental FS.

2.1. Site Conceptual Model for Vapor Intrusion

On 3 October 2002, EPA requested additional air sampling data to further evaluate the potential migration of VOCs from the groundwater to indoor air in commercial buildings at the MEW Companies' former facilities. A conceptual model was developed to aid the evaluation. The conceptual model identifies potential sources of VOCs in indoor air, defines chemicals of concern, and identifies potential pathways and receptors. The model also incorporates data from the air sampling field investigations.

Sources of VOCs: Potential indoor exposure to VOCs could result from one or a combination of the following sources:

- Volatilization from the subsurface soil or groundwater into a building structure,
- Occupational, household or consumer product use in or outside of the workplace or home (background indoor air),
- Contribution from outdoor air moving into a building through opened doors or windows, or air intakes of HVAC systems. This outdoor air can include contributions from offsite background concentrations, nearby industrial emissions (e.g., drycleaners), and volatilization from the subsurface to outdoor air near the building.

Chemicals of Concern (COCs): Air samples were analyzed for COCs defined in the 1989 ROD and detected in the groundwater. Based on the results of groundwater and air sampling conducted to date at the Site, the potential COCs for the vapor intrusion pathway are TCE; tetrachloroethene (PCE); cis- and trans-1,2-dichloroethene (cis-1,2-DCE; trans-1,2-DCE); vinyl chloride; chloroform; 1,1-dichloroethane (1,1-DCA); 1,1-dichloroethene (1,1-DCE); 1,2-dichlorobenzene (1,2-DCB); 1,1,1-trichloroethane (1,1,1-TCA); and trichlorotrifluoroethane (Freon 113).

Pathways: Volatile chemicals may volatilize from the groundwater or from soils, migrate upward through voids and cracks in the floors, dry conduits, or subsurface structures (e.g., basements and other subsurface structures), and enter buildings. For buildings with deep enough basements, groundwater may intrude onto the basement floor where VOCs may volatilize directly from the groundwater collected on the basement floor into the indoor air. Receptors in the buildings could inhale these vapors.

Potential Receptors: Potential receptors are persons in current and future residences and commercial buildings in the Vapor Intrusion Study Area overlying the shallow groundwater plume at the Site (Figure 2-1).

2.2. Remedial Investigation for Vapor Intrusion

Indoor air concentrations of COCs can be attributed to facility or occupational sources (e.g., sources attributed to building construction and use), volatilization from the subsurface into the building and contributions from outdoor air.

2.2.1. Types of Samples

The types of samples collected at the Site include indoor, pathway, outdoor, background (outdoor), and quality assurance samples.

2.2.2. Basis for Evaluation of Results

There are no promulgated cleanup standards for VOCs in the air. However, there are several guidance values that can be used to assist risk assessors and others in initial screening-level evaluations of environmental measurements. These include: 1) background and outdoor air concentrations; 2) short-term indoor air risk-based screening levels; and 3) long-term indoor air preliminary remedial goals. Indoor air results are compared to these values.

EPA Region 9 has published preliminary remediation goals (PRGs) for certain VOCs in indoor air. PRGs are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements, but are not cleanup standards. For this Site, EPA is using an action level for TCE of 1 microgram per cubic meter ($\mu g/m^3$) for residential occupancy and 5 $\mu g/m^3$ for commercial/non-residential occupancy. EPA Region 9 derived these action levels using a provisional health protective range for TCE and the California EPA (Cal/EPA) health-based screening level for long-term exposure to TCE. Prior to August 2008, EPA had used interim action levels of 1 $\mu g/m^3$ for residential occupancy and 2.7 $\mu g/m^3$ for commercial occupancy; accordingly, those interim action levels were used to guide the Supplemental Remedial Investigation work. Chapter 5 of this document provides further detail on the selection of the action levels.

2.2.3. Supplemental RI Results

Approximately 2,800 air samples have been collected from 47 commercial buildings and 31 residences at the Site (Figures 2-2, 2-3, and 2-4). The Supplemental RI concluded the following:

- There are no intermediate or short-term risks.
- Low concentrations of chloroform, PCE, TCE, Freon 113, and 1,1,1-TCA are frequently found in outdoor air. Some outdoor and background (outdoor) air samples had TCE concentrations above the interim action level.
- The following conditions enhance the potential for vapor intrusion of TCE to exceed concentrations above long-term exposure goals inside buildings: i) when commercial building ventilation systems do not provide sufficient outdoor make-up air in all or part of a building, ii) when the building has a basement or subsurface structure that approaches or intercepts contaminated groundwater, and iii) when utility conduits provide a preferential pathway for vapor intrusion into the building enclosure.
- In addition, as demonstrated in one particular case, there is a potential for vapor intrusion if an HVAC system is designed to supply air through a sub-floor panel that creates a zone of negative pressure

underneath the raised floor, induces VOC migrations from the subsurface, and pulls the VOCs from the sub-floor panel into the building.

- TCE is the primary chemical of concern for vapor intrusion at the Site.
- Interim mitigation measures implemented at the Site were successful in decreasing TCE to below the interim action level in the indoor air breathing zone, with the exception of TCE concentrations in an occasionally occupied wet basement in a commercial building. The building was sold and vacated in 2007, and commercial redevelopment plans indicate the building will be demolished.

2.2.4. Commercial Buildings Evaluated in the Supplemental RI

A total of 66 commercial buildings are located within the estimated 5 µg/L TCE plume boundary south of U.S. Highway 101, 40 of which have been sampled. For the remaining 26 buildings (Figure 2-5),

- The MEW Companies negotiated access with owners/tenants of 18 buildings and conducted walkthroughs with EPA to collect building information such as structure type, use, and layout, as well as HVAC system information.
- Access was provided for one building, but a walkthrough has not been conducted because the building has not been finished and is unoccupied.
- Owners of two buildings denied access. Contact information for these buildings has been provided to EPA for follow-up.
- Owners of five buildings did not respond to several mailings and telephone calls requesting access for a walkthrough. Contact information for these buildings has been provided to EPA for follow-up.

It is estimated that 101 commercial and 14 residential buildings overlie the estimated 5 µg/L TCE plume boundary north of U.S. Highway 101 on Moffett Field. Forty-one commercial buildings are within the Navy's West-side Aquifers Treatment System (WATS) area, where the Navy is addressing impacted groundwater by operating a groundwater extraction and treatment system. Seventeen additional buildings are in areas over suspected Navy sources that have not been investigated. The Navy has declined to participate in this Supplemental RI/FS process, and it is not known if the Navy will implement the Vapor Intrusion remedy in its area of responsibility.

NASA plans to redevelop a 213-acre parcel of Moffett Field into NASA Research Park, which will include research, educational and residential facilities. Of the estimated 115 buildings over the Vapor Intrusion Study Area north of U.S. Highway 101, information provided by NASA reveals the following:

- 36 buildings are unoccupied and will be demolished;
- 2 buildings are unoccupied, are planned to be demolished, but may be leased before demolition occurs;
- 30 buildings are currently occupied, but are planned to be demolished;
- 6 buildings are unoccupied, but are planned for lease;
- 34 buildings are occupied and will remain in use;
- 3 buildings are unoccupied, but future use is unknown; and
- 3 buildings are occupied, but future use is unknown.

2.2.5. Residential Area West of Whisman Road and Wescoat Housing Area

Between 2004 and 2008, EPA sampled indoor air at 17 residences (Residences 1 to 17) and has been communicating the results to those residents. The sampled residences are located in a residential area west of Whisman Road in an area defined by the estimated 5 µg/L TCE contour line (Figure 2-4) plus 100 feet. In 2002-2004, the Navy and EPA sampled several unoccupied units in the Wescoat Housing area. Three of the residential units were also in buildings located along the western portion of the shallow TCE groundwater plume boundary on Moffett Field. The 20 residences sampled include different types of building construction (slab-on-grade, crawlspace, basement, and earthen cellar) and provide a good spatial distribution of samples in the residential areas.

Residential sampling found TCE concentrations in one home with an unoccupied earthen cellar and two unoccupied residential units in Wescoat Housing that exceeded the residential interim action level of 1 µg/m^3 of TCE. A ventilation system was installed in the cellar, reducing the concentrations in the home to below the interim action level. The residences in the Wescoat Housing Area were demolished and vapor barriers and passive sub-slab ventilation systems were incorporated into the design of the new Wescoat Village housing area.

TCE was also detected in a few samples in three other homes west of Whisman Road at concentrations higher than the interim action level, but no mitigation measures have been warranted because these concentrations were not consistent with subsequent samples or follow-up revealed the elevated concentrations were associated with indoor sources in the home, and not vapor intrusion.

2.2.6. Data Analyses and Findings

The Supplemental RI analyzed the data to identify building similarities, determine data gaps, if any, and provide information to be used in the Supplemental FS. TCE was the focus of this analysis. Confirmation samples collected after implementation of interim mitigation measures showed that the mitigation measures resulting in reduced indoor air concentrations of TCE also resulted in reduced air concentrations for other chemicals of concern, if the source of these chemicals was from subsurface vapor intrusion.

The Supplemental RI supports the following conclusions regarding variables affecting indoor air concentrations detected in buildings:

- Indoor air results indicate there are no intermediate or short-term health concerns.

- In some commercial buildings within the Vapor Intrusion Study Area, TCE was detected above the 2.7 µg/m^3 interim action.

- The highest indoor TCE concentrations and most frequent percentage of concentrations greater than interim action level of 2.7 µg/m^3 were found in a building with a basement in which there is direct contact with groundwater (644 National Avenue). Elevated concentrations were also found in a NASA building in which the ventilation system introduced air from beneath the raised floor into the building (N210).

- In those buildings where samples were collected both when HVAC systems were on and off for an extended period of time, samples collected when the HVAC system was off generally had significantly higher TCE concentrations than samples collected when the HVAC system was on. A 10-fold reduction in TCE air concentrations was observed in a majority of cases when the HVAC system was on when compared to when the HVAC system was not operating. There is a general decrease of TCE concentrations with increasing air exchange rates.

- In commercial buildings with slab-on-grade construction, TCE concentrations were not detected above the 2.7 $\mu g/m^3$ TCE interim action level when the buildings were occupied and standard building occupancy ventilation was operating properly (with the exception of some isolated maximum values that were not consistent with co-located, previous, or subsequent sample results).

- In general it appears that buildings overlying the higher groundwater concentrations have a higher likelihood of indoor air samples exceeding the TCE interim action level of 2.7 $\mu g/m^3$.

- Vapor intrusion resulting in concentrations above interim action levels in commercial buildings appears to be more likely to occur at the Site when the HVAC system does not provide sufficient air exchanges with outside air in all or part of a building.

- The TCE air concentrations were reduced after implementation of discrete mitigation measures (i.e., sealing conduits, enhanced ventilation, and/or air purification systems).

- In most cases there is no significant difference in measured TCE concentrations between building floors with similar ventilation conditions. When TCE exceeded the interim action level, the floor immediately above the subsurface (basement or 1st floor) had higher concentrations than the others.

- With the exception of one residence that was found to have an indoor source of TCE, and two residences in which a single concentration exceeding the long-term exposure goal could not be subsequently confirmed, the residences showed TCE below the interim action level of 1.0 $\mu g/m^3$. Two unoccupied residences with slab-on-grade construction in Wescoat Housing area on Moffett Field showed TCE concentrations higher than the long-term exposure goal. The residences were subsequently demolished to build new residences. The new residential development with vapor intrusion mitigation measures was installed beneath the slab foundation in the Wescoat Village housing area.

- Seasonal temperature variation does not appear to have a significant effect on measured indoor TCE air concentrations at the Site.

3. MITIGATION MEASURES IMPLEMENTED

The Supplemental RI established that several buildings and residences at the Site had one or more samples in which TCE concentrations exceeded interim action levels for long-term exposure for indoor air. Vapor intrusion resulting in concentrations above interim action levels appear to be more likely to occur at the Site when: i) commercial building ventilation systems do not provide sufficient air exchanges with outside air in all or part of a building ii) the building has a basement or earthen cellar, or iii) utilities provide a preferential pathway for vapor intrusion into the building enclosure. In addition, there is a potential for vapor intrusion if an HVAC system is designed to supply air through a sub-floor panel that creates a zone of negative pressure underneath the raised floor, induces VOC migration from the subsurface, and pulls the VOCs from the sub-floor panel into the building. Interim mitigation measures were implemented in buildings where these conditions existed and indoor air concentrations exceed the TCE interim action level. A discussion of these mitigation measures and an evaluation of their effectiveness are presented here.

3.1. 401 National Avenue

This building did not have an operating HVAC system at the time samples were originally collected. Original sampling before implementing remedial measures detected TCE in indoor air at concentrations ranging from 0.14 to 51 $\mu g/m^3$. In pathway samples collected in an unoccupied utility room, TCE was detected at concentrations ranging from 50 to 74 $\mu g/m^3$. Subsequently, in August 2003, Fairchild/Schlumberger sealed cracks and dry conduits in the utility room of this building. Following the sealing work, Fairchild/Schlumberger conducted a test by starting the HVAC system in the office portion of the building. Because the HVAC system had not been operated at the building for a while, it created unacceptable dust and heat and was operated for only 1.5 hours. Further work in the utility room was completed in March 2004 by reconnecting the existing exhaust fan to the electrical source and installing ducting to enhance the ventilation in the interior portions of the building. After mitigation, TCE was detected in indoor samples at concentrations ranging from 0.2 to 2.2 $\mu g/m^3$; in the utility room, TCE detections ranged from 2.3 to 6.4 $\mu g/m^3$.

The effectiveness of the interim mitigation measures can also be demonstrated by comparing the concentrations of other constituents before and after implementation. For example, before mitigation, detection of cis-1,2-DCE concentrations varied between 1.1 and 13 $\mu g/m^3$ in indoor samples and between 13 and 18 $\mu g/m^3$ in the utility room. After mitigation, cis-1,2-DCE was measured at concentrations between 0.17 and 0.87 $\mu g/m^3$ in indoor air. In the utility room, cis-1,2-DCE concentrations ranged from 0.48 to 1.4 $\mu g/m^3$.

3.2. 644 National Avenue

This building did not have an operating HVAC system at the time samples were originally collected, and had a basement where groundwater percolates onto the basement floor. Before implementation of mitigation measures, TCE was detected in the basement at concentrations from 190 to 490 $\mu g/m^3$. On the first and second floors, TCE concentrations ranged between 15 and 94 $\mu g/m^3$.

In August 2003, Fairchild/Schlumberger sealed the elevator shaft and openings in the basement floor, including the sumps. In addition, Fairchild/Schlumberger sealed several openings in the floor between the basement and the first floor and installed two exhaust fans in the basement, each with a capacity of 6,000 cubic feet per minute (cfm).

Following the mitigation work, Fairchild/Schlumberger conducted a test by starting the fans in the basement and collecting confirmation air samples the following week. Subsequently, the owner requested that the fans operate only at night instead of 24 hours per day. A timer was installed on the exhaust system to operate between 12 AM and 6 AM. After mitigation, TCE concentrations in the basement varied between 14 and 43 $\mu g/m^3$ (14 $\mu g/m^3$ was measured when the ventilation system was operating 24 hours per day and 43 $\mu g/m^3$ was measured when the system was operating for 6 hours per day). On the first and second floor, TCE concentrations ranged from 0.24 to 0.59 $\mu g/m^3$. The basement in the building had not been routinely occupied for several years.

The effectiveness of the exhaust system in the basement could also be demonstrated by comparing the concentrations of other constituents before and after installation of the system. For example, before mitigation, cis-1,2-DCE concentrations ranged from 64 to 190 $\mu g/m^3$ in the basement and from 8.2 to 41 $\mu g/m^3$ on the first and second floor. After mitigation, cis-1,2-DCE concentrations ranged from 3 to 6.5 $\mu g/m^3$ in the basement, but the chemical was detected in only one of 11 samples on the other floors at a concentration of 0.14 $\mu g/m^3$. Significant reductions in concentrations were also observed for vinyl chloride and 1,1-DCA.

The mitigation measures were successful in isolating the basement's indoor air concentrations from the first and second floors. Limited groundwater continued to be observed leaking into the basement, however, which acted as a source of VOCs into the basement air.

The building was sold in 2007 and vacated. Commercial redevelopment plans include demolishing the building, including the basement.

3.3. 355/365 E. Middlefield Road

Initial findings showed indoor air TCE concentrations ranging from less than 0.19 to 1.4 $\mu g/m^3$, below EPA's interim action level. Certain pathway samples collected in a crack showed TCE above 2.7 $\mu g/m^3$, EPA's interim action level. Subsequently, Intel contracted an HVAC specialist to service and retrofit the HVAC system for this building. Repairs included replacing all filters, changing fluids, replacing fan belts, adjusting the dampers for outdoor air intake and installing a damper on a unit that did not provide outside make-up air. The air exchange rate was increased to 1.2 per hour.

Following HVAC repair and improvements, Intel collected confirmation air samples in September and December 2003 to assess TCE concentrations in the indoor air breathing zone and along the floor cracks. All confirmation air samples showed TCE concentrations below the EPA interim action level. For example, maximum TCE concentrations in pathway samples were reduced from 49 $\mu g/m^3$ prior to mitigation to 0.62 $\mu g/m^3$ post-mitigation. And while indoor air TCE concentrations were already below outdoor levels and EPA's interim action level prior to mitigation, concentrations were further reduced post-mitigation.

3.4. 501 Ellis Street

The building has a ventilation system, with 13 roof-mounted HVAC units supplying conditioned air to the two separate building areas. Initial indoor air sampling results in the building were within long-term exposure goals. Results of a follow-up sampling event detected TCE at one location at concentrations ranging from 4.5 to 5.8 $\mu g/m^3$, above EPA's interim action level of 2.7 $\mu g/m^3$, in an unoccupied portion of the building. However, it was found that only three of eight HVAC units that service the unoccupied area were operating when that sample was collected. Also, a potential vapor intrusion pathway, a fire sprinkler test drain, was discovered during the follow-up sampling event.

All eight HVAC units that service the unoccupied portion of the building were restarted (the HVAC system continued to operate in the occupied portion of the building) and the fire sprinkler test drain was plugged. Signage was also posted near the fire sprinkler test drain to alert building personnel to the presence of the plug. Subsequent indoor air sampling results were below EPA's interim action level.

3.5. 370 Ellis Street, Building A

Samples taken from this building prior to performing any mitigation measures showed TCE concentrations in an unoccupied area, Room A106, of 170 $\mu g/m^3$. Room A106 is known as the Intermediate Distribution Frame (IDF) Room. Although there was a second room that shared some of the characteristics of Room A106 (Room A112, which is known as the unoccupied Switch Gear Room), no pre-mitigation sampling was taken from that area. (As noted below, post-mitigation sampling was taken from both rooms.)

Because both of these rooms were connected to deep underground utility vaults where groundwater was observed and where VOCs had accumulated, Raytheon decided to implement mitigation measures in each room, even though both are typically unoccupied and the concentrations found in these rooms did not cause increases in concentrations in the nearby occupied areas to levels above EPA's interim action level of 2.7 $\mu g/m^3$.

As a first step, Raytheon sealed the conduits in both rooms (A106 and A112) and then collected confirmation samples. In room A106, where pathway samples were collected before implementation of mitigation measures, the sealing of the conduits resulted in a significant decrease in concentrations. TCE concentrations in Room A106 decreased from a maximum of 170 $\mu g/m^3$ to a maximum of 13 $\mu g/m^3$. Freon 113 decreased from a maximum of 24 $\mu g/m^3$ to a maximum of 7.2 $\mu g/m^3$; 1,1,1-TCA decreased from a maximum of 8.7 $\mu g/m^3$ to a maximum of 2.3 $\mu g/m^3$. PCE remained virtually unchanged, indicating indoor sources of PCE. TCE samples taken after the conduits in Switch Gear Room A112 were sealed showed results ranging from 2.1 $\mu g/m^3$ to 5.8 $\mu g/m^3$.

After sealing the conduits, Raytheon performed a pilot test in room A106. An air purification system was installed in the room in April 2004 and a series of confirmation samples were collected. The system consists of a 55-gallon carbon vessel, which circulates the air in the room through the carbon. VOCs in the air adsorb onto the carbon, which is changed periodically. A noise abatement hood is provided with the unit to reduce the noise in the room, and the system is plugged into an 110V outlet for power. Room A106 is suitable for such a system because the IDF rooms are enclosed, fire-proof, and cooled using an air re-circulation system that is not supplied with outside make-up air.

After installation of the air purifier in Room A106, confirmation sampling demonstrated that TCE concentrations were reduced further. The TCE concentration in the most recent sample collected in February 2008 was not detected above the laboratory detection limit of 0.18 $\mu g/m^3$. This represents a three-order of magnitude decrease in TCE concentrations when compared with the initial sampling, which occurred before the mitigation measures were implemented.

Based on the success of the pilot test, Raytheon installed a similar air purification system in Room A112 in November 2005 and collected confirmation air samples. The detected TCE concentration in the most recent sample collected in February 2008 was 1.0 $\mu g/m^3$.

3.6. 370 Ellis Street, Building B

Samples taken from Building B prior to the performance of any mitigation measures showed TCE concentrations in an unoccupied area, Utility Room B102, up to 1.7 µg/m³. IDF Room B104 shared some of the characteristics of Room B102, but no pre-mitigation sampling was taken from that area. (As noted below, post-mitigation sampling was conducted in both rooms.)

Similar to Building A, both rooms were connected to deep underground utility vaults where groundwater had collected and VOCs had accumulated. Raytheon decided to perform mitigation measures in each room, even though both are typically unoccupied, and the concentrations found in these rooms did not cause increases in concentrations in the nearby occupied areas to levels above EPA's interim action level of 2.7 µg/m³.

As a first step, Raytheon sealed the conduits in both rooms and then collected confirmation samples. In Room B102 where pathway samples were collected before implementation of mitigation measures, the most recent sample collected in February 2008 showed TCE at 0.2 µg/m³. TCE concentrations in IDF Room B104 were up to 18 µg/m³ after the conduits were sealed.

Because of the success of the air purification system pilot test in Building A, Raytheon installed an air purification system in IDF Room B104 in November 2005 and collected confirmation samples. The most recent confirmation sample collected in February 2008 showed TCE at 0.47 µg/m³, demonstrating a significant decrease in concentrations.

3.7. 380 Ellis Street, Building C

Samples taken from Building C prior to performing any mitigation measures showed TCE concentrations in an unoccupied area, IDF Room C110, up to 310 µg/m³. Pre-mitigation samples in another unoccupied area, Utility Room C113 did not detect TCE. Utility Room C102 shared some of the characteristics of Room C113 – no pre-mitigation sampling was conducted in that area. (As noted below, post-mitigation samples were taken from both rooms.)

These rooms were connected to deep underground utility vaults where groundwater had collected and where VOCs had accumulated. Raytheon decided to perform mitigation measures in each room, even though both are typically unoccupied, and the concentrations found in these rooms did not cause increases in concentrations in the nearby occupied areas to levels above EPA's interim action level of 2.7 µg/m³.

As a first step, Raytheon sealed the conduits in all three rooms and then collected confirmation samples. In Room C110 where pathway samples were collected before implementation of mitigation measures, sampling showed TCE at 6.5 µg/m³, representing a two orders of magnitude decrease in concentrations. Low-level TCE concentrations were detected in Room C113 (up to 0.79 µg/m³). Similarly, confirmation samples from utility C102 showed low-level TCE concentrations (up to 0.56 µg/m³).

Because of the success of the air purification system pilot test in Building A, Raytheon installed an air purification system in IDF Room C110 in November 2005 and collected confirmation samples. The most recent confirmation sample collected in February 2008 showed TCE at 0.25 µg/m³, demonstrating a three-order of magnitude decrease in concentrations compared to pre-mitigation samples.

3.8. 380 Ellis Street, Building D

Samples taken from Building D prior to performing any mitigation measures showed TCE concentrations in an unoccupied area, Utility Room D112, up to 5.1 $\mu g/m^3$. IDF Room D106 shared some of the characteristics of Room D112, but no pre-mitigation sampling was conducted in that area. (As noted below, post-mitigation samples were taken from both rooms.)

Because these rooms were connected to deep underground utility vaults where groundwater had collected and VOCs had accumulated, Raytheon decided to perform mitigation measures in each room, even though both are typically unoccupied, and the concentrations found in these rooms did not cause increases in concentrations in the nearby occupied areas to levels above EPA's interim action level of 2.7 $\mu g/m^3$.

Raytheon sealed the conduits in both rooms and then collected confirmation samples. In Room D112 where pathway samples were collected before implementation of mitigation measures, the most recent sample collected in February 2008 showed TCE at 1.1 $\mu g/m^3$. In IDF Room D106, the most recent sample collected in July 2008 showed TCE at 1.6 $\mu g/m^3$.

3.9. 350 Ellis Street, Building E

Samples taken from Building E prior to performing any mitigation measures showed TCE concentrations in an unoccupied area, IDF Room E132, up to 48 $\mu g/m^3$. Utility Room E114 shared some of the characteristics of Room E132, but no pre-mitigation samples were taken from that area. (As noted below, post-mitigation samples were collected from both rooms.)

Because both of these rooms were connected to deep underground utility vaults where groundwater had accumulated and VOCs had accumulated, Raytheon decided to perform mitigation measures in each room, even though both are typically unoccupied, and the concentrations found in these rooms did not cause increases in concentrations in the nearby occupied areas to levels above EPA's interim action level of 2.7 $\mu g/m^3$.

Raytheon sealed the conduits in both rooms and then collected confirmation samples. In IDF Room E132, where pathway samples were collected before implementation of mitigation measures, the most recent sample collected in February 2008 did not show TCE, representing a more than two orders of magnitude decrease in concentrations. In Utility Room E114 the most recent sample showed TCE at 1.1 $\mu g/m^3$.

3.10. 487 E. Middlefield Road

Indoor air samples in this building showed concentrations within or below EPA's long-term exposure goals. Nevertheless, in September 2003 SMI sealed some readily accessible conduits in the electrical room as a precautionary measure to reduce the potential for vapor migration.

3.11. 425 National Avenue

In 2004-2007, this building was vacant and did not have an operating HVAC system. TCE concentrations in the unoccupied building ranged between 7.1 and 8.7 $\mu g/m^3$. To reduce observed indoor air concentrations in this building, Vishay/SUMCO sealed the elevator shaft in April 2004. Vishay/SUMCO collected additional samples in 2007 and 2008 after the HVAC system was installed and operational in the building.~~.~~ In the 2007 sampling event, indoor air samples from the building ranged from 0.63 to 1.0 $\mu g/m^3$, with one concentration on the second floor at 3.9 $\mu g/m^3$. As tenant improvements had been completed just prior to the 2007 sampling event, indoor air samples were again collected in 2008. The 2008 indoor air samples ranged from 0.45 to 1.2 $\mu g/m^3$.

3.12. NASA Building 15

TCE was detected at concentrations ranging from 0.23 to 4.9 $\mu g/m^3$. NASA adjusted the HVAC system in May 2003 to increase the outside air supplied into this building. The mitigation measures implemented in Building 15 reduced the indoor air concentrations to concentrations ranging from 0.35 to 1.2 $\mu g/m^3$.

3.13. NASA Building N210

Initial sampling in this building showed TCE concentrations in indoor air between 0.22 and 176 $\mu g/m^3$, with the highest concentration measured in an access corridor, which is not continuously occupied. Lower TCE concentrations were measured in the interior building, but some of these concentrations were higher than the interim action level. This building formerly had an HVAC system that supplied air through ducts into the sub-floor plenum; the air was then pushed into the interior of the building through open grates in the floor. Because this configuration enhanced vapor migration into the building, the duct system was rearranged so that the air is supplied through a network from the ceiling. All grates in the sub-floor were replaced with solid floor tiles and all protrusions through the existing floor tiles were sealed. In addition, NASA installed an exhaust system for the sub-slab plenum to induce a negative pressure there.

In January and February 2006 NASA collected 110 indoor air, pathway and outdoor ambient samples from 21 locations on the first, second and third floors to confirm the effectiveness of these HVAC modifications. The confirmation samples showed that the modifications to the HVAC system reduced the TCE air concentrations to below the interim action level (NASA~~,~~ 2007).

3.14. 555 Ellis Street

As a precautionary measure, two HVAC units in this building were retrofitted to add dampers and increase the outside make-up air supply into the building. After retrofitting, the air exchange rate was measured at 1.2 per hour. Concentrations in indoor air measured after the retrofits were below EPA’s action level. Samples were not collected before retrofitting the two HVAC units.

3.15. 460 E. Middlefield Road

As a precautionary measure, dampers were added to certain HVAC systems in this building to increase the supply of outside make-up air. Samples collected after the retrofits showed TCE concentrations below or within EPA's long-term exposure goals. Samples were not collected before retrofitting the HVAC units.

3.16. 660 National Avenue

Initial sampling of this building showed TCE in indoor air ranging between 0.19 and 9 $\mu g/m^3$. Subsequently, the HVAC system for this building was refurbished to provide additional outside make-up air and to better ventilate all portions of the building. After the HVAC system was refurbished, confirmation samples were collected at all six previously sampled locations. The confirmation samples showed non-detectable TCE concentrations and all other chemical of concern below EPA's interim action levels.

3.17. Evaluation of Interim Mitigation Measures

The following is a summary evaluation of the effectiveness of the mitigation and precautionary measures discussed above. Detailed analyses can be found in the Supplemental RI report.

- Sealing of open dry conduits that penetrate the sub-slab: In general, sealing dry conduits resulted in decreased concentrations of VOCs transmitted through the conduits.

- Refurbishing HVAC systems to supply additional outside make-up air: HVAC systems have been shown to be an effective method to reduce indoor air concentrations primarily by providing outside make-up air to the indoors.

- Installation of exhaust/ventilation systems in sub-slab structures (basements, earthen cellars) and in utility rooms: Ventilation of utility rooms and sub-slab structures is effective in reducing indoor air concentrations to below long-term exposure goals. However, the effectiveness of ventilation in a basement where groundwater impacted with VOCs accumulates may be limited.

- Installation of air purification systems to reduce indoor air concentrations in enclosed utility rooms: Air purification systems have been demonstrated to be effective in reducing indoor air concentrations to below the interim action level in enclosed utility rooms.

In addition to the interim and precautionary mitigation measures described in Sections 3.1 to 3.16, two other mitigation technologies were implemented at the Site during redevelopment of two properties:

- Sub-slab pressurization: This type of system was installed at a new commercial development at 425-495 N. Whisman Road. Sampling of the sub-slab pressurization system installed during the development of 8 commercial buildings on the property showed that such a system would be effective in preventing vapor migration into buildings.

- Installation of vapor barriers and passive ventilation systems under new residential development: Indoor samples were collected from 10 residences at a new residential development, the Wescoat Village housing area, on Moffett Field, where homes were constructed with a vapor barrier and a sub-slab passive ventilation system, showed TCE below EPA's interim action level.

4. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121(d) of CERCLA requires that remedial actions at Superfund sites achieve (or justify the waiver of) any state and federal environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. This section identifies applicable or relevant and appropriate requirements (ARARs) affecting the vapor intrusion remedy at the Site. ARARs already identified in the 1989 ROD also apply to the vapor intrusion portion of the remedy.

ARARs are state or federal cleanup standards, controls, or provisions that specifically address the hazardous substances, remedial action being taken, location, or other site circumstance ("applicable" requirements) as well as those standards, controls or provisions that do not directly or fully address specific site activities but address similar situations or problems likely to be encountered as determined on a site-specific basis (i.e., "relevant and appropriate" requirements). Federal ARARs are those requirements under any federal environmental law. State ARARs are those requirements that are more stringent or broader in scope than federal requirements. In those cases where California state law delegates enforcement authority to local agencies that develop and implement state requirements, local regulations may also be ARARs. Requirements that are not federal or state requirements, are not environmental in nature, or are not substantive are not ARARs. However, they may be applied to activities at the Site by the relevant regulating authority.

An ARAR may be either "applicable" or "relevant and appropriate" but not both. If there is not a specific federal or state ARAR for a particular remedial action, compliance with the remedial action is technically impracticable, or if the existing ARARs are not considered sufficiently protective, then other criteria or guidelines may be identified for consideration and used to ensure the protection of public health and the environment.

ARARs fall into three categories: chemical-specific, location-specific, and action-specific ARARs. Chemical-specific ARARs are health or risk-based restrictions on the mass or concentration of chemicals remaining in, or discharged to, a given media. Location-specific ARARs set restrictions on certain types of activities based on characteristics of the site locale. Action-specific ARARs govern particular activities or technologies involved in a remedy and aim to control discrete actions.

4.1. Chemical-Specific ARARs

Soil and groundwater cleanup standards for VOCs and metals at the Site were set in the 1989 ROD.

EPA sets site-specific cleanup levels in one of two ways. Where there is a regulatory standard for exposure to a chemical at a Site, cleanup levels may be set at that standard. EPA may also set site-specific risk-based cleanup levels which apply specifically to the contaminants and exposures at the Site. The risk analysis can be based on multiple sources, including chemical-specific ARARs and To-Be-Considereds (TBCs).

4.1.1. EPA Region 9 Action Levels

Although cleanup standards for VOCs in air have not yet been promulgated, three EPA Regions published a harmonized set of Regional Risk Screening Levels (RSLs) (EPA 2009a), formerly known as EPA Region 9

Preliminary Remediation Goals or PRGs (EPA 2004a) for certain VOCs. RSLs are risk-based concentrations used to assist risk assessors and others in initial screening-level evaluations of environmental measurements, but are not themselves cleanup standards. The RSLs are general in that they are calculated without site-specific information.

For this Site, EPA used the RSLs and site-specific information to determine site-specific risk-based action levels. Specifically, for indoor air at this Site, EPA is using action levels for TCE of 1 and 5 $\mu g/m^3$ for residential and commercial worker/non-residential occupancy, respectively. EPA derived the action levels using the EPA provisional health protective range for TCE and the Cal-/EPA's health-based screening level for long-term exposure to TCE, both TBCs.

4.2. Location-Specific ARARs

4.2.1. Fault Zone

The Site is not located within 200 feet of a geological fault. Therefore, the fault zone requirement of 40 CFR 264 is satisfied.

4.2.2. Floodplain

A hazardous waste treatment facility located in a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood. The Site is not located in a floodplain so these requirements are not ARARs.

4.3. Action-Specific ARARs

Action-specific ARARs depend on the type of remedial alternative chosen. This section describes only the action-specific ARARs associated with remedial actions related to vapor intrusion that have been implemented at the Site or that may be implemented in the future.

4.3.1. Air Emissions

Bay Area Air Quality Management District Regulation 8, Rule 47: Bay Area Air Quality Management District (BAAQMD) regulations promulgated at Regulation 8, Rule 47 address emission control requirements for organic compound emissions from air stripping and soil vapor extraction systems. This Rule is potentially relevant and appropriate for emissions of VOCs from active sub-slab depressurization systems or sub-membrane depressurization systems. Rule 47 requires a control device reducing emissions by at least 90 percent by weight for those operations which emit benzene, vinyl chloride, PCE, methylene chloride and/or TCE. BAAQMD Regulations § 8-47-301. Section 8-47-301 does not apply if the operation emits no more than one of the following compounds: benzene, vinyl chloride, TCE, PCE, or methylene chloride, and if benzene emissions do not exceed 0.05 pounds per day, vinyl chloride emissions do not exceed 0.2 pounds per day, or TCE, PCE, or methylene chloride emissions do not exceed 0.5 pounds per day. BAAQMD Regulations § 8-47-109.

Additionally, the provisions of Section 8-47-301 do not apply to operations with total emissions of less than one pound per day of benzene, vinyl chloride, PCE, methylene chloride, and/or TCE, unless those emissions subsequently rise to over one pound per day. BAAQMD Regulations § 8-47-113.

Bay Area Air Quality Management District Regulation 8, Rule 40: BAAQMD Regulation 8, Rule 40 is potentially relevant and appropriate to activities during the construction phase of the chosen remedial actions. Where more than 8 cubic yards of contaminated soil is removed for construction of a remedial system beneath buildings at the Site, and where the soil has organic content above 50 parts per million weight (ppmw), Section 8-40-304 would require that inactive storage piles be appropriately covered.

4.3.2 Land Use Covenants

Title 22 of the California Code of Regulations Section 67391.1 requires the placement of recorded land use covenants at properties where hazardous materials, hazardous wastes or constituents, or hazardous substances will remain at levels not suitable for unrestricted use of the land. Section 67391.1 acknowledges that there may be circumstances where it is determined that placement of a land use covenant is not feasible, and, in those instances, other institutional control mechanisms may be used to ensure that future land use will be compatible with the level of hazardous substances left on the property.

4.4. To Be Considereds (TBCs)

California Human Health Screening Levels (CHHSLs)

State of California Human Health Screening Levels, or "CHHSLs", developed by the Office of Environmental Health Hazard Assessment (OEHHA) on behalf of the California Environmental Protection Agency (Cal/EPA 2005) may be used as TBCs in development of site-specific risk-based soil gas criteria for the vapor intrusion remedy. While not cleanup levels, CHHSLs are contaminant screening levels in soil gas that the State of California believe conservatively predict whether there is a long -term risk of vapor intrusion exposure at a property, or specific portions of properties.

5. EXPOSURE GOALS

There are no promulgated cleanup standards for VOCs in the air. However, there are several guidance values that can be used to assist risk assessors and others in initial screening-level evaluations of environmental measurements. These include:

- Background and outdoor air concentrations
- Short-term exposure goals
- Long-term indoor air preliminary remedial goals

These guidance values are discussed further below.

5.1. Background and Outdoor Air Concentrations

In California, chloroform, PCE, TCE, vinyl chloride and 1,1,1-TCA are routinely monitored in outside air at stations maintained by both the BAAQMD and the California Air Resources Board (CARB). The closest monitoring station to the Site was the BAAQMD monitoring station located in Mountain View at 160 Cuesta Drive, approximately 2 miles from the Site. While in operation, outside air sampling was conducted at this station approximately every 12 days. Summary statistics for this BAAQMD sampling station for the most recent three years of sampling (1997 to January 2000) revealed PCE concentrations ranging between 0.07 and 4.7 $\mu g/m^3$ and TCE from non-detect levels to a maximum concentration of 7.4 $\mu g/m^3$.

During the remedial investigation work, air samples were collected at a number of EPA-specified locations surrounding the Site. These are referred to as "reference" samples (Figure 5-1). In addition, background outdoor samples taken 1 to 1.5 miles away from the Site (Figure 5-2) were also collected. Reference and background outdoor samples were collected to coincide with the indoor air sampling events conducted at the Site. In addition to the reference and background outdoor samples collected by the MEW Companies and NASA, the BAAQMD installed a temporary monitoring station at Whisman Park and collected 50 samples from this station approximately every 12 days during 2004 and 2005. TCE was detected in 6 samples with a maximum concentration of 0.54 $\mu g/m^3$.

Further, onsite outdoor samples were collected on the same day as indoor air samples during each building sampling event. Outdoor samples were collected on rooftops (e.g., next to an HVAC unit inlet) or at ground level outside the building if the building did not have an HVAC system. Results of outdoor samples were compared to those of indoor samples to assess the contribution from outdoor air to indoor air quality.

Consideration of potential risks related to exposure to background outdoor concentrations of chemicals provides perspective on the relative significance of the indoor air concentrations under consideration. For example, Cal/EPA estimates that the cancer risk from breathing current levels of pollutants in California's outside air over a 70-year lifetime is 750 x 10^{-6} http://www.oehha.ca.gov/pdf/HRSguide2001.pdf. Locally, the BAAQMD estimates a cancer risk from breathing outside air in the Bay Area of 160 x 10^{-6} (http://www.baaqmd.gov/pmt/air_toxics/annual_reports/2002/rpt02-final.pdf). These background risk estimates exceed 1×10^{-6}, which provides perspective on the relative risks associated with an individual maximum indoor air sample result.

5.2. Action Levels - Short-Term Exposure

The Agency for Toxic Substances and Disease Registry (ATSDR) has developed acute (14-day) and intermediate (15-365 day) minimal risk levels (MRLs) applicable to short-term exposure periods. Acute and intermediate MRL is an estimate of the daily human exposure to a chemical that is likely to be without appreciable risk of adverse non-cancer health effects over a specified short-term duration of exposure. These chemical specific estimates, which are intended to serve as screening levels, are used by ATSDR health assessors and other responders to identify COCs and potential health effects that may be of concern at sites. EPA is using measured indoor air concentrations and comparing to MRLs to assess short-term risks. Table 5-1 lists Action Levels for Short-term Exposure for the MEW Site COCs.

Table 5-1: Action Levels for Short-term Exposure

MEW Site Chemical of Concern	Action Levels for Short-Term Exposure ($\mu g/m^3$)	
	Acute (14 days)	Intermediate (15-365 days)
TCE	11,000	540
PCE	1,400	Not Available
Cis-1,2-DCE	Not Available	Not Available
Trans-1,2-DCE	800	800
Vinyl Chloride	1,300	80
Chloroform	490	240
1,1-DCA	Not Available	Not Available
1,1-DCE	Not Available	80
1,2-DCB	Not Available	Not Available
1,1,1-TCA	10,000	3,800
Freon-113	Not Available	Not Available

5.3. Action Levels – Long-Term Exposure

In November 2008, EPA Regions 3, 6, and 9 published a harmonized set of Regional Screening Levels (RSLs), formerly referred to by Region 9 as Preliminary Remediation Goals or PRGs (see EPA, 2004a and 2009b). The air RSLs are applicable to both indoor and outdoor air and are based on either a long-term residential exposure scenario or a long-term indoor worker exposure scenario. Action Levels can be developed based on promulgated standards or a risk-based approach. RSLs are risk-based tools and are not promulgated cleanup standards. They are used for site screening and as initial cleanup goals if applicable. RSLs are not *de facto* cleanup standards and should not be applied as such. However, they may be helpful during the analysis of different remedial alternatives. For more information on RSLs, see EPA Region 9's website: http://www.epa.gov/region09/waste/sfund/prg/index.html

Table 5-2 shows EPA's proposed Action Levels for Long-term Exposure for Residential and Commercial Buildings for the MEW Site.

Table 5-2: Action Levels for Long-term Exposure - Residential and Commercial Buildings for the MEW Site

MEW Site Chemical of Concern	Action Level ($\mu g/m^3$)		Comments
	Residential	Commercial	
TCE	1	5	Representing 10^{-6} lifetime target cancer risk through application of the Cal/EPA toxicity factor and a 10^{-4} lifetime target cancer risk through application of draft 2001 EPA toxicity factor.
PCE	0.4	2	Representing 10^{-6} lifetime target cancer risk.
Cis-1,2-DCE	60	210	Not Available. Based on trans-1,2-DCE Non-cancer Hazard Index = 1.
Trans-1,2-DCE	60	210	Representing Non-cancer Hazard Index = 1.
Vinyl Chloride	0.2	2	Representing 10^{-6} lifetime target cancer risk. EPA uses a larger conversion factor from residential to commercial for vinyl chloride because the residential value takes into account child exposure and higher sensitivity earlier in life.
Chloroform	0.1	0.4	Representing 10^{-6} lifetime target cancer risk.
1,1-DCA	2	6	Representing 10^{-6} lifetime target cancer risk.
1,1-DCE	210	700	Representing Non-cancer Hazard Index = 1.
1,2-DCB	210	700	Representing Non-cancer Hazard Index = 1.
1,1,1-TCA	5,200	18,000	Representing Non-cancer Hazard Index = 1.
Freon-113	31,000	100,000	Representing Non-cancer Hazard Index = 1.

Over the course of finalizing the FS, new draft EPA guidance (Risk Assessment Guidance for Superfund, Part F (EPA, 2009a) and User's guide became available to EPA risk assessors (*User's Guide to Risk Assessment for Response Actions at CERCLA Sites* http://www.epa.gov/ reg3hwmd/risk/human/rb-concentration_table/usersguide.htm# parameters). EPA recommends the use of a new inhalation exposure equation to derive risk-based guidelines for air. This new equation leads to slightly different indoor air target concentrations for indoor air for long-term exposure than the previous equation that was based on earlier guidance (Risk Assessment Guidance for Superfund, Part A, EPA 1989b)[1].

[1] The previous 1989 and new 2008 equations are presented in Appendix C for occupational/indoor worker exposures, where the application of the new equation leads to an approximate two-fold increase of the resulting target concentration for indoor workers.

At this Site, EPA is using site-specific information for the indoor worker exposure time. The RSLs use a default worker exposure time of 8 hours per day. Here during the Supplemental Remedial Investigation, EPA adopted a site-specific worker exposure time of 10 hours per day. The resulting TCE action level for indoor worker is 5 µg/m^3 using a 10-hour workday (after rounding). Therefore, EPA has estimated the exposure goals used in this FS by substituting 8 hours with 10 hours into the equations resulting in an adjustment factor of 0.8.

5.3.1. TCE Indoor Air Action Level

For this Site, EPA Region 9 is using indoor air action levels for TCE of 1 µg/m^3 for residential occupancy and 5 µg/m^3 for commercial indoor worker occupancy, which EPA Region 9 derived considering both the range of draft cancer toxicity values provided by the EPA (2001) and the current Cal/EPA cancer toxicity value for long-term exposure to TCE. The action level for TCE in air is a risk-based concentration and is derived to be protective against carcinogenic risks associated with long-term exposure to TCE in residential or workplace settings.

For residential exposure, the action level is derived based on the following equation:

$$C = [TR \times AT] / [IUR \text{ x } ET_r \text{ x } EF_r \times ED_r]$$

Where:

C	=	Target concentration of 1 µg/m^3 derived by EPA for residential settings
TR	=	10^{-6} through application of the Cal/EPA Office of Environmental Health Hazard Assessment (OEHHA) inhalation unit risk (IUR) and upper end of risk range through application of draft 2001 EPA IUR.
AT	=	Cancer averaging time, 70 years expressed in days (25,550 days)
IUR	=	Inhalation unit risk, 0.000002 (per µg/m^3) from Cal/EPA and 0.00011 (per µg/m^3) from EPA, 2001
ET_r	=	Exposure time (residential), 24 / 24 (total hours per 24 hr-day)
EF_r	=	Exposure frequency (residential), 350 days per year
ED_r	=	Exposure duration (residential), 30 years

The action level for indoor workers is derived through the same equation as follows:

$$C = [TR \times AT] / [IUR \text{ x } ET_w \text{ x } EF_w \text{ x } ED_w]$$

Where:

C	=	target concentration of 5 µg/m^3 derived by EPA for commercial settings
TR	=	10^{-6} through application of the Cal/EPA IUR and upper end of risk range through application of draft 2001 EPA IUR

AT = Cancer averaging time, 70 years expressed in days (25,550 days)

IUR = Inhalation unit risk, 0.000002 (per $\mu g/m^3$) from Cal/EPA

ET_w = Exposure time (indoor worker), 10 / 24 (total hours per 24 hr-day)

EF_w = Exposure frequency (indoor worker), 250 days per year

ED_w = Exposure duration (indoor worker), 25 years

5.3.2. Interpretation of TCE Action Level

The action level for the Site addresses long-term exposure to TCE and either a 10^{-4} risk through application of the most conservative (health-protective) toxicity value derived by EPA's draft report (2001) or a 10^{-6} risk through application of the toxicity value recommended by Cal-/EPA. Each of the values represents long-term exposure at that concentration (i.e., 24 hours per day, 350 days per year for 30 years for the residential value and 10 hours per day, 250 days per year for 25 years for the indoor worker value). These assumptions represent health-protective residential and workplace exposure scenarios.

Because these risk-based concentrations are linear, exposure for a shorter time-period would equate to a lower risk and exposure for a longer time period would equate to a higher risk. Thus, if a worker accesses a TCE affected area briefly, works shorter days or less often, or works at that location for fewer than 25 years, risks may be lower. For example, if a workplace area is only accessed 25 days per year, instead of 250 days per year, the potential long-term risks associated with the 5 $\mu g/m^3$ indoor worker action level would be reduced ten-fold.

5.3.3. Status of the EPA Draft TCE Toxicity Values

There are currently no established EPA toxicity values for TCE on the Integrated Risk Information System (IRIS). The prior value has been withdrawn from IRIS and the IRIS file for TCE states the following: "The carcinogen assessment summary for this substance has been withdrawn following further review." EPA's 2001 draft health risk assessment of TCE underwent extensive review within EPA, including a peer review by EPA's Science Advisory Board (SAB), which provided a peer review report in December 2002.

In addition, the public submitted more than 800 pages of comments to EPA during a 120-day public comment period. In February 2004, EPA held a public symposium on new TCE science in which a number of authors of recently published scientific research presented their findings. Due to continuing science issues as well as emerging significant new science, further revision and external review have been planned.

EPA, along with the Department of Defense, Department of Energy, and NASA, cosponsored a consultation on TCE science issues with an expert panel convened by the National Academy of Sciences (Board on Environmental Studies and Toxicology. EPA developed four issue papers that highlight important scientific issues related to TCE. These papers were provided to the National Academies' National Research Council (NRC) panel in February 2005. A report on the NRC panel's findings and recommendations entitled *Assessing the Human Health Risks of Trichloroethylene, Key Scientific Issues* was released in July 2006 (National Academies Press 2006). The report recommended that EPA finalize the TCE risk assessment with currently available data so that risk management decisions can be made.

EPA plans to incorporate the advice from the NRC panel review, respond to comments from the EPA Science Advisory Board and the public, and include recently published scientific literature into another revision to EPA's draft TCE health risk assessment. This revised assessment will then undergo both external peer review and public comment prior to being finalized *(see http://cfpub.epa.gov/ncea/cfm/ recordisplay.cfm?deid=119268).*

5.3.4. Basis of the Cal/EPA Cancer Toxicity Value (IUR)

OEHHA derived an inhalation unit risk (IUR) of 0.000002 $(ug/m3)^{-1}$ based on the geometric mean of four IURs derived from inhalation studies in animals that showed excesses of liver cancer (Maltoni et al. 1986, as cited in Maltoni et al. 1988; Bell et al. 1978, as cited in Rhomberg 2000), lymphoma (Henschler et al. 1980), and lung cancer (Fukuda et al. 1983). This value is verified by OEHHA (OEHHA 2002, 2005) at this time, and is also specifically derived to represent inhalation risks.

5.3.5. Evaluation of Potential After-Hours Exposure

Workers may be present in buildings in addition to or outside of a 10-hour workday (i.e., during weekends and weekday evenings). Workers that are present during non-regular workday hours may include janitorial and maintenance staff or professional staff that are working when ventilation systems are not in operation (i.e., weekends and after-hours).

The TCE action level of 5 $\mu g/m^3$ for commercial buildings is based on an exposure scenario that assumes continuous exposure for 10- hour workday, 250 days/year, over 25 years, through application of the draft upper-end of the risk range toxicity value derived by EPA or a 10^{-6} risk through application of the Cal/EPA toxicity value. If workers are present in the building less often, risk would be lower. For example, if a worker works only 5 hours per day instead of 10 hours the reduced exposure time provides a safety factor of 2 (estimated risks would be half as much). The same is also true if the exposure concentration, the exposure duration, or exposure frequency is less than the exposure assumptions used to determine the 5 $\mu g/m^3$ action level.

6. IDENTIFICATION AND INITIAL SCREENING OF REMEDIAL TECHNOLOGIES

The purpose of the initial screening of remedial technologies is to develop an appropriate range of technologies that can address the potential vapor intrusion pathway at the Site. Each of the technologies is screened based on three criteria: 1) effectiveness, 2) implementability, and 3) cost. The retained technologies are combined, if appropriate, into remedial alternatives to create options that are evaluated in the detailed analysis of remedial alternatives (Chapter 7).

6.1. Evaluation Criteria for Technology Initial Screening

In accordance with the EPA's RI/FS guidance (EPA 1988), the initial screening of remedial technologies is performed using three evaluation criteria:

Effectiveness: This evaluation focuses on i) the potential effectiveness of the technology in handling the estimated area or volume of air and meeting the remediation goals identified in the remedial action objectives, ii) the potential impacts on human health and the environment during construction and implementation of the remedy, and iii) how proven and reliable the process is with respect to the chemicals and Site conditions.

Implementability: This evaluation includes both the technical and administrative feasibility of implementing the technology. The evaluation includes an assessment of institutional aspects of implementability, such as the ability to obtain permits, the availability of treatment methods, and the availability of the necessary equipment and skilled workers.

Cost: Cost typically plays a limited role in this initial screening process. In this evaluation, each technology is screened as to whether its costs are high, low, or moderate relative to other technologies.

Detailed cost estimates associated with each of these technologies are provided in Tables 6-1 and 6-2 for the commercial and residential scenarios, respectively. The estimates include capital and annual O&M costs. For the commercial scenario, costs were developed for a typical one-floor, 20,000 square-foot building. For the residential scenario, the costs were developed for a typical 2,000 square-foot residence. When applicable, a range of costs (low and high) was estimated. Present worth analyses were performed to compare costs for each alternative. These analyses used a discount rate of 7 percent, which is consistent with the rate used for non-federal facilities according to EPA guidance (EPA, 1990c).

The estimates of capital cost for each technology consist of direct costs (construction equipment, labor, materials, services, and disposal) and indirect costs (non-construction and overhead: engineering, financial, licensing or permits, startup/shakedown, and contingencies). Annual O&M costs are the post-construction costs necessary to verify the continued effectiveness of the technology. Annual costs include operating labor costs, maintenance materials and labor expenses, auxiliary materials and utilities, disposal of any residuals, administrative costs and monitoring/support costs.

Cost estimates were developed using several sources that included published construction cost data, vendor quotes, and engineering judgment. The sources of the published cost data are:

- R.S. Means Building Construction Cost Data, 2006;

- R.S. Means Environmental Remediation Cost Data, 2005; and
- R.S. Means Heavy Construction Cost Data, 2003.

Building Construction Cost Data were used in most cases, but if the relevant data were not available in that publication, one of the other two publications was used. The values taken from Heavy Construction Cost Data were adjusted for inflation from 2003 to 2006. This was done by comparing the cost increase of a similar task common to both Building Construction Cost Data and Heavy Construction Cost Data, and applying the percentage of increase to the cost shown in the Heavy Construction Cost Data. All R.S. Means cost data were adjusted for a location differential, in this case, by a Means recommended factor of 1.16 for San Jose, California.

In some instances, these costs were further adjusted to reflect the small quantity being installed or added installation difficulty. An example of increased installation difficulty would be retrofit construction. In some instances, a range of cost values was used. This generally reflects the uncertainty that usually exists regarding specific construction design or materials that may be used.

6.2. Remedial Action Objectives

The RAOs for the Site established in the 1989 ROD were to reduce levels of chemicals in groundwater (and chemical sources to groundwater) so that the groundwater could ultimately be used for domestic and drinking water purposes. At that time, no RAOs for the vapor intrusion pathway were identified. RAOs typically specify the chemicals of concern, the exposure route and an acceptable chemical level or range of levels.

The RAO to be addressed by the vapor intrusion remedy is to ensure that building occupants (workers and residents) are protected from Site contaminants by preventing the contaminants in the subsurface from migrating into indoor air or accumulating in enclosed building spaces at levels of concern.

Another RAO for the Site is to reduce or minimize the source of vapor intrusion (i.e. Site contaminants in shallow groundwater) to levels that would be protective of current and future building occupants such that the need for a vapor intrusion remedy would be minimized or no longer be necessary. This RAO will not be addressed by the proposed vapor intrusion remedy; instead, it will be addressed by the groundwater remedy which is being re-evaluated in a separate feasibility study for the Site.

6.3. General Response Actions

Technologies are grouped into seven general response action categories for the purpose of an initial screening:

1. No Action: No action would be taken to address vapor intrusion at the Site.
2. Monitoring: This excludes engineering controls, but includes monitoring for vapor intrusion (e.g., groundwater, indoor air, soil gas).
3. Physical Barriers: Physical barriers would be designed to lower indoor air concentrations by physically blocking vapor migration from the subsurface to buildings.
4. Sub-Surface Pressure Control: This type of remedial measure would be designed to prevent vapor migration into indoor air using a subsurface pressure differential to force soil gas flow away from the building enclosure.

5. Point-of-Exposure Measures: These technologies would be designed to directly reduce air concentrations in the occupied space.
6. Institutional Controls (ICs): ICs are administrative and legal tools that do not involve construction of engineering controls or physical changes to the Site. EPA recognizes four types of ICs: 1) government controls, 2) proprietary controls, 3) enforcement tools, and 4) informational devices. Screening and detailed evaluation of ICs are provided separately in Chapter 8 of this document.

6.4. Identification of Technologies

The technologies proposed in this Supplemental FS are focused on the vapor intrusion pathway and address the prevention of human exposure to COCs at levels of concern by reducing indoor air concentrations or preventing the pathway from impacting indoor air quality. Technologies considered in this Supplemental FS for the vapor intrusion pathway are grouped into the five general response action categories as follows:

1. No Action: No action would be taken to address vapor intrusion. Some characterization may occur to establish that no action is needed.

2. Monitoring: Including groundwater, indoor air, and/or soil gas.

3. Physical barriers include:

   - Vapor barriers;
   - Modified soil barriers;
   - Modified on-grade foundations;
   - Conduit sealants; and
   - Surface coatings;

4. Subsurface pressure control measures include:

   - Sub-slab passive ventilation;
   - Sub-slab pressurization;
   - Sub-slab depressurization;
   - Sub-membrane depressurization; and
   - Air injection curtains

5. Point-of-exposure measures include:

   - Exhaust of indoor space;
   - HVAC system; and
   - Air purification/filtration

6.5. Initial Screening of Technologies

This subsection describes and screens the various technologies listed above and presents the results of the initial screening. Each of the technologies is screened based on three criteria: 1) effectiveness, 2) implementability, and 3) cost.

6.5.1. No Action

In this option, no action would be taken to address the vapor intrusion pathway at the Site. Under applicable regulatory guidance, the no-action alternative is included in the detailed analysis.

Inherent in the no action option is natural ventilation because all buildings experience, at a minimum, natural ventilation through open doors and windows.

6.5.2. Monitoring

This option does not include construction of engineering controls. Monitoring could be one or a combination of the following:

1. Groundwater Monitoring: Groundwater samples collected from monitoring wells at the Site provide information on the plume concentrations and plume boundaries. Groundwater concentrations and water level measurements may be able to help assess whether the potential for vapor intrusion is increasing or decreasing. Definition of the plume boundaries would indicate if the Vapor Intrusion Study Area (Figure 2-1) should be modified.

2. Indoor air samples: Indoor air samples provide empirical information on the concentrations of VOCs in the enclosed space. Vapor intrusion investigation at the Site included collection of approximately 3,000 indoor and outdoor air samples, which were used in defining conditions under which a building may need engineering controls to mitigate the vapor intrusion pathway.

3. Soil gas samples: Many vapor intrusion guidance documents specify soil gas samples as one line of evidence in evaluating vapor intrusion (ITRC 2007, Cal/EPA 2005). Sufficient soil gas samples collected spatially apart and at multiple depths to just above the water table may provide information to assess the potential vapor intrusion into a building. The vapor intrusion investigation at the Site included limited soil gas samples to evaluate the vapor intrusion pathway. Site-specific data and other lines of evidence would be necessary to screen out a property for vapor intrusion.

<u>Effectiveness:</u> Monitoring can be used to evaluate changes in the potential for vapor intrusion. Trends in groundwater concentrations in an area provide information to evaluate if the potential for vapor intrusion is increasing or decreasing. Indoor air samples provide empirical data on concentrations of VOCs, and confirm that concentrations remain below long-term exposure goals. In addition, monitoring could be effective for buildings where natural ventilation provides adequate air exchanges with outside air (e.g., warehouses, residences); in this case, monitoring can confirm that an engineering control is not necessary and that natural ventilation is sufficient to reduce indoor air concentrations attributed to vapor intrusion to below long-term exposure goals. Monitoring only (i.e., without engineering controls) is not effective for buildings where indoor air concentrations result in unacceptable health risks.

Implementability: Monitoring is implementable in existing and in new commercial or residential buildings where access has been granted. It uses proven procedures and standard practices. Access from property and building owners is needed to collect samples. Monitoring wells have been installed at the Site to evaluate the trends in concentrations and the plume boundaries. Additional groundwater monitoring wells may be needed to further define discrete locations within the plume or further define the extent of the plume boundary. Access will have to be obtained from property owners and building occupants to allow collection of air or soil gas samples when necessary.

Cost: The cost of monitoring is typically low. Groundwater monitoring can be achieved using existing monitoring wells, indoor air samples require no permanent structures, and soil gas samples are economical. Soil gas samples are typically collected at multiple depths, including just above the water table.

Screening: Monitoring has been used at the Site to evaluate vapor intrusion. In some cases, when engineering controls are not necessary, monitoring can be used as a stand-alone alternative to confirm that vapor intrusion does not result in concentrations higher than action levels. This alternative is retained for further analyses.

6.5.3. Physical Barriers

In this option, physical barriers would be designed to lower indoor air concentrations by physically blocking vapor migration from the subsurface into building enclosures using the technologies discussed below.

6.5.3.1. Vapor Barriers

Vapor barriers resist chemicals migration. They are made in a variety of textures and densities, each one specific to different situations. Vapor barriers could be either synthetic liners or seamless, spray-applied membranes.

Smooth synthetic liners are more tailored to situations where containment of water or hazardous wastes is necessary. Textured liners provide stability so that the liner is likely to stay in place even when it is placed on a slope. Conductive textured liners are stiffer and stronger than the other textured products, which allow them to be useful in areas where containment is crucial. Inspection and testing of conductive liners after installation is easier because the conductive products have a layer of carbon that conducts electricity. This allows the installer to easily locate tears after installation.

High-density polyethylene (HDPE) geomembrane liners have three layers of material. The material is stiff, strong, and resistant to tears and punctures. The correct installation and welding of the HDPE liner is of paramount importance because the integrity and long-term performance of the liner depends on it. The seaming of the liner is carried out by hot wedge welding, which provides a double welded seam with a test channel. The installation of HDPE liner is performed by qualified installers. HDPE liners are rodent and root resistant.

Linear low-density polyethylene liners (LLDPEs) are more flexible than HDPE liners and can be elongated in one or more directions allowing the liner to accommodate unsettled ground. High puncture elongation properties make LLDPE liners ideal where conforming to sub grade irregularities increases the possibility of puncture. LLDPE is fusion and extrusion welded onsite. Puncture-resistant liners should be used.

Polyvinyl chloride (PVC) liners are thinner and more flexible than polyethylene liners due to the type of resin used. PVC liners are very easy to patch or seam together. They are less susceptible to stress, heat or thermal expansion due to the amorphous structure of the chemical and can stretch to conform to the ground, even if it moves.

Liquid Boot®, manufactured by LBI technologies, Inc., consists of a cold, water-based (does not contain any VOCs), seamless, monolithic spray-applied membrane used as a vapor barrier. It is typically sprayed to a thickness of 60-100 mils over a base fabric. For new construction, it is applied under the concrete slab and sealed to all footings and pipe penetrations. Another type of product manufactured by LBI is Liquid Boot "Waterproofing;" this could be applied to basements with floors beneath the groundwater table to serve the dual purposes of preventing groundwater infiltration into the basement and acting as a barrier against vapor intrusion.

Effectiveness: Vapor barriers have been used historically to prevent migration of VOCs into buildings. One such application, coupled with a passive venting system, has recently been implemented on Moffett Field in the Wescoat Housing area. Their effectiveness depends on the design and installation quality as well as on long-term maintenance. For example, future modifications to building structures should avoid puncturing the barrier. Vapors also may leak through improperly sealed seams around utility penetrations.

This technology is protective of worker's health during construction. Standard construction procedures are used, and licensed contractors are typically used for the installation. There are no additional risks or impacts on the environment during the implementation of this technology. This technology is designed to be effective for new commercial developments and for residential buildings. Because vapor barriers at the Site have been used only in conjunction with a passive venting system (e.g., Wescoat Housing Area), the reliability of this technology as a stand-alone technology has not been tested. To mitigate vapor intrusion, this technology is typically combined with others to increase effectiveness.

Implementability: This technology can be implemented in new commercial or residential developments, but not for existing structures (except for Liquid Boot® which could be applicable for exposed floors). For new construction, it uses proven procedures and standard construction practices. Services and materials to implement this technology are available. Licensed contractors are typically used for the installation. The barrier should not be compromised after initial installation, such as during building modifications or installation of new utilities. Building permits are necessary to install a vapor barrier.

Cost: The costs of vapor barriers, while they vary with the size of the structure and the type of barrier, are moderate.

Screening: The effectiveness of this technology depends on the design and installation quality as well as on long-term maintenance. Because vapor barriers at the Site have been used only in conjunction with another technology, the reliability of this technology as a stand-alone technology has not been tested. Therefore, this technology is retained for alternatives development, but only in combination with other technologies.

6.5.3.2. Modified Soil Barriers

This technology consists of applying a bentonite-soil mixture under a building to create a barrier with minimum air pores that would prevent vapors from migrating upwards. This technology is also used as a measure to minimize differential settlement.

Effectiveness: Soil barriers are typically used to avoid differential settlement. At the same time, the barrier limits migration of VOCs into buildings because the bentonite-soil mixture creates a low-permeability barrier under the building against upward migration of VOCs. The effectiveness of soil barriers depends on the design and installation quality. Drying may limit the effectiveness of the barrier.

This technology was used at the Site during the development of the properties on 313/323 Fairchild Drive, 464/466/468 Ellis Street, and 369/379/389/399 N. Whisman Road. Indoor air samples collected from the buildings on these properties consistently showed concentrations of VOCs below EPA's long-term exposure goals. However, this could be due to a combination of factors, including building ventilation by HVAC systems. Therefore, the reliability of this technology as a stand-alone technology has not been tested; it is typically combined with other technologies to increase effectiveness.

This technology is protective of worker's health during construction. Standard construction procedures are used, and there are no additional risks or impacts on the environment during the implementation of this technology. This technology is designed to be effective for new commercial and residential buildings.

Implementability: This technology can be implemented in new commercial or residential developments, but not under existing structures. It uses proven procedures and standard construction practices.

Normal monitoring/verification practices are typically used during construction to verify the integrity of the barrier. The barrier should not be compromised in future building modifications. Services and materials to implement this technology are available. Building permits are necessary to implement a modified soil vapor barrier.

Cost: The costs of this technology, while it varies with the size of the structure and the type of barrier, are moderate.

Screening: This technology has been used at the Site, but only as a duplicative layer to another technology, such as HVAC system. Because this technology is commonly used in practice to minimize differential settlement rather than to mitigate vapor intrusion, and because the effectiveness of this technology in limiting vapor intrusion into buildings is not well documented, it is screened from alternatives development.

6.5.3.3. Modified On-Grade Foundation

On-grade modified building foundations include monolithic concrete pours, which limit cold joints, low air entrainment, post-tension reinforcement, and thickened-mat slabs. In a monolithic concrete pour, the foundation is poured all at once and then separated into several smaller divisions before it dries. By breaking it into sections, the foundation is less likely to crack when the ground settles.

Air entrainment is critical to foundations in areas where the ground temperature falls below the freezing point. As concrete dries, air pockets form due to the evaporation of water. Later, water will fill these pockets when moisture collects in the area. As the temperature drops, the water will expand as it freezes. Cracks will begin to form near these air pockets as the water continues to freeze and thaw if there are not enough air pockets in the concrete. Low air entrainment practices can be followed in areas where the ground rarely freezes, and VOCs will not be able to migrate easily into the building through the foundation if there are fewer air pockets available.

Post-tension reinforcement protects the foundation from unstable ground. Joints in post-tension concrete are minimized and sometimes eliminated.

Effectiveness: This technology may not result in indoor air concentrations below long-term exposure goals because it reduces, but does not eliminate, pathways through the building slab. This technology is protective of worker's health during construction. Standard construction procedures would be implemented. There are no additional risks or impacts on the environment during the implementation of this technology.

Implementability: This technology can be implemented in new commercial or residential developments. In new construction it uses proven procedures and standard construction practices. Building permits are necessary. Services and materials to implement this technology are readily available.

Cost: The costs of modified on-grade foundations, while they vary with the size of the structure and the type of barrier, are high.

Screening: This technology may not result in indoor air concentrations below long-term exposure goals because it reduces, but does not eliminate, pathways through the building slab. Because the reliability of this technology has not been proven, and it is not known if this technology would result in indoor air concentrations below long-term exposure goals when implemented as a primary measure, it is screened from alternatives development.

6.5.3.4. Conduit Sealants

Conduit sealants can be used to seal dry conduits that serve as a direct pathway for vapors from the subsurface to the building enclosure. Types of conduit sealants include expanding foam, pourable polyurethane, adhesives, expandable plugs, and caps. For example, expandable sealants can be used on dry conduits with electrical wires passing through them. Conduits that have been installed for future use (but with no utilities through them) can be sealed with caps.

Effectiveness: This technology addresses a specific potential pathway (conduits), and when applied as a stand-alone technology it is not sufficient to address other potential pathways. Sealing of dry conduits would eliminate vapor intrusion through these conduits. Seals are typically long lasting. Care should be taken in resealing the conduits following any modifications to the utilities.

This technology has been used at the Site as a interim or precautionary measure (Sections 3.5 to 3.10 of this document, or refer to the Supplemental RI report for additional details). Sealing of conduits resulted in significant reductions in indoor air concentrations when these conduits provided a direct pathway for VOCs from the subsurface.

This technology is protective of worker's health during construction. Standard construction procedures would be used. There are no additional risks or impacts on the environment during the implementation of this technology.

Implementability: This technology can be implemented in new and existing commercial and residential developments. It uses proven procedures and standard construction practices. Services and materials to implement this technology are readily available. No permits are necessary.

Cost: The costs of sealing conduits are low.

Screening: This technology is retained for alternatives development, but only as a supplement to another technology. When applied as a stand-alone technology, it is not sufficient to address other potential pathways.

6.5.3.5. Surface Coatings

Floors or cracks in floors can be sealed using expandable sealants to prevent the migration of VOCs into the building. Types of sealants include epoxy paints, asphaltic coatings, and polyurethane caulk. They can also be applied in the annulus around a conduit penetration.

Effectiveness: Coatings have been used historically as barriers against migration of VOCs into buildings from the subsurface. Their effectiveness depends on the design and installation quality as well as long-term maintenance. For example, the coating or seal would have to be reapplied in areas where modifications to building structures penetrate the coating or seal. Vapors may leak through improperly sealed seams around utility penetrations. This technology is typically applied in conjunction with others (such as HVAC systems, or sub-slab depressurization [SSD]).

This technology is protective of worker's health during construction. Only coatings that do not emit Site COCs should be used. Standard construction procedures would be used. There are no additional risks or impacts on the environment during the implementation of this technology.

Implementability: This technology can be implemented in new commercial or residential developments. In new construction, it uses proven procedures and standard construction practices. Application in existing buildings is limited to areas of exposed floor with readily accessible conduits. Sealants cannot be applied where carpeting or tile has been installed, and the sealant barrier should not be compromised during building modifications.

Services and materials to implement this technology are available. Building permits are necessary for application of this technology.

Cost: The cost varies with the type of coating, and can range from low to high.

Screening: This technology may be useful for limited applications, such as to seal cracks and joints in building foundations. However, because this technology would work in the same way as vapor barriers, but is not considered as reliable as vapor barriers in the short and long term, this technology is screened from alternatives development.

6.5.4. Subsurface Pressure Controls

This type of remedial measure prevents vapor migration into indoor air by applying differential pressure in the subsurface, below the building slab, to force soil-gas flow away from the building enclosure.

6.5.4.1. Sub-Slab Passive Ventilation

A sub-slab (or sub-membrane) passive ventilation system would include perforated pipes, within a gravel and/or sand layer, manifolded to vent risers. The vent risers typically end with a wind-driven turbine that would exert a slight negative pressure in the subsurface and induce flow from the subsurface to the outside. Alternatively, differential barometric pressures throughout the day can also generate a pressure differential and enhance the air flow. A sub-slab (or sub-membrane) passive ventilation system contains no active mechanical equipment. However, a passive ventilation system easily can be converted to an active ventilation system if designed accordingly.

Effectiveness: Although some chemicals would be removed from the gravel/sand layer through passive venting of the layer, some chemicals may migrate into the indoor air in the absence of other measures, such as vapor barriers, or in the presence of direct pathways, such as conduits, from the sub-slab to the building enclosure. Because this technology has been successfully used at the Site only in conjunction with vapor barriers (e.g., Wescoat Housing Area), its reliability as a stand-alone technology has not been tested.

This technology is protective of worker's health during construction. Standard construction procedures would be used. There are no additional risks or impacts on the environment during the implementation of this technology.

Implementability: This technology can be implemented in new commercial and residential developments at the Site. It uses proven procedures and standard construction practices. This technology may not be practical for large existing structures, and is not appropriate for structures with basements beneath the water table.

Other than standard building permits, no permits are necessary. Services and materials to implement this technology are readily available.

Cost: Although the cost of this technology varies with the size of the building, the cost of a sub-slab (membrane) passive ventilation system is moderate.

Screening: Because this technology has been successfully used at the Site only in conjunction with a vapor barriers (e.g., Wescoat Housing Area), its reliability as a stand-alone technology has not been tested. Therefore, this technology is retained for alternatives development but would be combined with other technologies.

6.5.4.2. Sub-Slab Pressurization

A sub-slab pressurization (SSP) system introduces outside air to a layer of gravel and/or sand that is placed just beneath the building foundation. A small positive pressure builds in this layer by forcing outside air into the pore spaces. The pressurized layer eliminates convective flow of vapors from the underlying soils. The air that is pushed into the space under the slab moves across the gravel and typically leaves through exhaust vents that are located around the building edges.

Effectiveness: Concentrations in the gravel layer would likely be similar to outdoor concentrations because VOCs would be removed from the gravel/sand layer through introduction of outdoor air into the layer. Consequently, vapor intrusion is not likely to result in concentrations greater than long-term exposure goals. If direct conduits are present, the positive pressure may induce flow into the building through seams around the conduits; so this technology should be combined with a physical barrier technology to prevent such an occurrence. .

Penetrations of the sub-slab should be handled carefully to avoid short-circuiting of air though direct openings into the building, and modifications to the building that involve penetration of the sub-slab should provide for proper sealing of openings. This technology was used as a precautionary measure in a recent commercial development at the Site at 425-495 N. Whisman Road. Analytical testing showed that the VOC concentrations the sub-slab gravel annulus air were similar to outdoor air, demonstrating the effectiveness of this technology.

This technology is protective of worker's health during construction. Standard construction procedures would be used. There are no additional risks or impacts on the environment during the implementation of this technology.

Implementability: This technology can be implemented in new commercial and residential developments. In new construction, it uses proven procedures and standard construction practices. This technology may not be practical for large existing structures, and is not appropriate for structures with basements beneath the water table. Other than standard building permits, no permits are necessary. Services and materials to implement this technology are readily available.

Cost: While cost varies with the size of the building, the cost of a sub-slab pressurization system is high.

<u>Screening:</u> If direct conduits are present, the positive pressure resulting from this technology may induce flow into the building. This technology is retained for alternatives development but would be used in combination with another technology to prevent pressurized flow into the building.

6.5.4.3. Sub-Slab Depressurization

A SSD system typically consists of a sub-slab sand/gravel layer with a piping system and blower. The system is operated to create a slight negative pressure under the building slab, thus inducing flow of soil gas into the pipe. Should cracks be present in the building, the SSD induces a flow from the building into the lower pressure area under the slab. Air from the SSD system is vented outside the building. Depending on the emissions, the vented air may require treatment.

<u>Effectiveness:</u> A SSD system would remove VOCs from under the building slab, and the negative pressure under the building slab would overcome the pressure inside the building. Consequently, the vapor intrusion pathway would be eliminated and this technology would not result in concentrations greater than long-term exposure goals. SSD systems have been shown to be highly effective in controlling vapor intrusion in both new and existing structures. This technology is protective of worker's health during construction. Standard construction procedures would be used. There are no additional risks to the environment during the implementation of this technology. Depending on the emission rate of VOCs, exhaust air from the SSD system may have to be treated and/or permitted.

<u>Implementability:</u> This technology can be implemented in new commercial and residential developments. It uses proven procedures and standard construction practices. This technology can also be implemented in existing single-family residences. Implementability for existing large or densely equipped buildings is limited because these buildings may require multiple application points (in comparison with one for a single family home), trenching inside the building footprint for pipes, and disruption to operations or building features. Implementation in warehouses, however, may be more feasible because warehouses typically have accessible open spaces that could allow for installation of multiple application points with associated piping to the roof (e.g., along structural beams) or to the outside (by trenching through the warehouse floor). If horizontal piping is to be installed, then existing foundations would prevent the pipes from being installed near the slab, which would reduce the effectiveness of the SSD system. This technology cannot be implemented in structures with basements beneath the water table.

Depending on the emission rate of VOCs, the BAAQMD may require a permit. Otherwise, only standard building permits would be required. Services and materials for this technology are readily available.

<u>Cost</u>: While the cost varies with the size of the building, the cost of a sub-slab depressurization system is high for commercial applications and low for single-family residences.

<u>Screening</u>: This technology is retained for alternatives development.

6.5.4.4. Sub-Membrane Depressurization

An SMD system is similar to an SSD system except that it is installed below a membrane instead of a slab, when slabs are absent, such as in buildings with crawlspaces. The membrane prevents short circuiting of air during depressurization of the soil. The SMD creates lower sub-membrane air pressure relative to the crawlspace air pressure by use of a fan powered vent to draw air from soils under the membrane. The membrane could consist of polyethylene materials or plastic liner sheeting placed over the earthen or gravel area. It must be sealed along the edges of the foundation wall or footings and at pipe penetrations through the membrane.

Effectiveness: The membrane prevents the flow of air to the building and the air beneath the membrane is removed and expelled outdoors using a fan powered vent. SMD has been shown to be effective in new and existing residential developments with crawlspaces (ITRC~~,~~ 2007).

This technology is protective of worker's health during construction. Standard construction procedures would be used. It is advisable to place pads over the membrane to allow building occupants to access the crawlspace without damaging the membrane. There are no additional risks to the environment during the implementation of this technology. Depending on the emission rate of VOCs, exhaust air from the SMD system may have to be treated and/or permitted.

Implementability: This technology can be implemented in both new and existing buildings with crawlspaces. Field applications of other sites have shown that a properly installed SMD system could reduce VOC concentrations by up to 99.5% (ITRC~~,~~ 2007). It uses proven procedures and standard construction practices.

Accessibility to the crawlspace could limit the implementability of SMD. For example, sufficient headspace should be present to allow placement of the membrane in the crawlspace, and subsequent seating to footings, wells and pipes. For structures having more than one crawlspace, each of those areas is treated as separate crawlspace. Multiple approaches may be required in buildings having both basement and crawlspace.

Depending on the emission rate of VOCs, the BAAQMD may require a permit. Otherwise, only standard building permits would be required. Services and materials for this technology are readily available.

Cost: The costs for the installation and O&M for SMD are similar to those of passive barriers and SSD, though post-mitigation, inspection, and repair cost may be higher.

Screening: This technology is retained for further analyses as a stand-alone alternative.

6.5.4.5. Air Injection Curtains

This technology involves a series of air-injection wells placed in a line between the source (e.g., groundwater plume, impacted soil) and structures. The barrier prevents horizontal migration of vapors through the subsurface.

Effectiveness: This technology may not result in indoor air concentrations below long-term exposure goals because it does not prevent the vertical migration of vapors. At this Site, the primary potential vapor migration pathway is vertical. This technology is not effective if the source of vapors (such as groundwater) is under the building, which is typically the case at the Site.

This technology is protective of worker's health during construction. Standard construction procedures would be used. There are no additional risks or impacts on the environment during the implementation of this technology.

Implementability: This technology can be implemented for new or existing structures.

Cost: The cost for air injection curtains is high.

Screening: This technology is not effective if the source of vapors (such as groundwater) is under the building, which is typically the case at the Site. Consequently, this technology is screened out from alternatives development.

6.5.5. Point-of-Exposure Measures

These measures are designed to directly reduce air concentrations at the point of exposure.

6.5.5.1. Exhaust of Indoor Space

Fan units remove (exhaust) air from within the structure with outside make-up air provided through doors, windows, or other openings. This kind of exhaust system is typical in warehouses with chemical uses, bathrooms (e.g., bathroom fans), and kitchens (e.g., kitchen fans). Exhaust can be mechanical, by operation of fans, or passive, by operation of wind-driven turbines installed typically in the ceiling (e.g., warehouses).

<u>Effectiveness:</u> Exhausting the ventilated area removes VOCs from the enclosure. Sufficient air exchange rates would reduce concentrations below long-term exposure goals. However, when applied to an entire building, air exhaust systems could create a negative pressure zone in the building, which may enhance vapor intrusion. Therefore, application of this technology should be limited to areas such as kitchens, bathrooms, or warehouses.

This technology can be protective of worker's health during construction. Standard construction procedures would be used. There are no additional risks to the environment during the implementation of this technology.

<u>Implementability:</u> This technology is implemented in new and existing commercial or residential developments. It uses proven procedures and standard construction practices. Standard building permits may be needed. Services and materials for this technology are readily available.

<u>Cost:</u> The cost of typical exhaust fans is low.

<u>Screening:</u> This technology may be useful for limited applications, when occupational conditions necessitate air exhaust (e.g., in bathrooms, kitchens, chemical usage areas), or in warehouses. However, because it is not applicable as a remedial technology for an entire building, it is not retained for alternatives development.

6.5.5.2. HVAC Systems

Mechanical ventilation provided by HVAC systems that convey outdoor air into the building enclosure has historically been used to improve the indoor air quality in buildings. CARB specifies ventilation as one method to improve the indoor air quality (CARB 2005). EPA documents also include ventilation as means to prevent or correct indoor air quality. For example, an EPA document refers to increasing the outdoor make-up air to improve the air quality (EPA 1991).

The net effect of ventilation by HVAC is an air exchange rate defined as the rate at which the indoor air is exchanged with outdoor air. For example, an air exchange rate of 1/hr means that indoor air is replaced with outdoor air each hour. If the HVAC system is operated at a high enough level, it induces positive pressure in the building enclosure and thereby eliminates or significantly reduces the migration of VOCs into the building; otherwise it acts simply to dilute the concentration of VOCs that have entered the building. During the remedial investigation, indoor air samples were collected from various buildings including air-tight buildings that may experience positive pressure and from leaky buildings that at a minimum have neutral pressure with the outside. Chapter 5 of the Supplemental RI report (Locus 2006b) provides a detailed analysis of air samples collected at the Site, and demonstrates a relationship between building ventilation and concentrations of VOCs in indoor air. In general, buildings with an air exchange rate of at least 1/hr showed TCE concentrations in indoor air significantly lower than the long-term commercial exposure goal for both air-tight buildings and leaky buildings.

Effectiveness: By exchanging the indoor air with outside air, VOCs are removed from the building enclosure. The Supplemental RI provides detailed analyses showing that buildings at the Site with sufficient air exchange rates have concentrations below long-term exposure goals, demonstrating the effectiveness of ventilation as a remedial technology.

This technology is protective of worker's health during construction. Standard construction procedures would be used. There are no additional risks to the environment during the implementation of this technology.

Implementability: This technology can be implemented in new and existing commercial and residential development; however, HVAC systems are not typically installed in residences. Most commercial buildings already have operating HVAC systems in place, or are constructed with HVAC systems built in. HVAC systems are not typically installed in warehouses, which rely on natural ventilation through roll-up doors, or passive ventilation through wind-driven turbines in the ceiling, or exhaust fans.

This technology uses proven procedures and standard construction practices. It is technically feasible and reliable, and technical problems are not foreseen. Management plans and verification of system operation may be necessary to verify proper operation of the systems. Standard building permits may be needed. Services and materials for this technology are readily available.

Cost: The cost to retrofit an existing HVAC system to allow for additional outside make-up air is low. The cost to install a new HVAC system is medium to high, depending on the size and use of the building.

Screening: Because this technology has been demonstrated to be effective in existing commercial buildings at the Site, it is retained for further analyses as a stand-alone alternative.

6.5.5.3. Air Purification

A typical air purification system consists of a carbon vessel and a blower. The blower draws air through the carbon vessel, which induces air circulation in the room. VOCs in the air adsorb onto the carbon, which is changed periodically. A noise abatement hood is typically available with the unit and the system is connected to an 110V outlet for power.

Effectiveness: By recirculating air through an air purification system, VOCs are removed from the enclosed space. This system is effective in enclosed areas in which make-up air is not mechanically supplied. Examples of such enclosures are utility or storage rooms. This technology is protective of worker's health.

The effectiveness of this technology has been demonstrated at the Site. Air purification systems were installed and operated in several enclosed utility rooms that did not have outside make-up air (see Sections 3.5 to 3.7 of this document and the Supplemental RI report for more details). VOC concentrations in these utility rooms decreased significantly after operation of the purifiers.

Implementability: This technology can be implemented in new and existing commercial and residential constructions. It uses proven procedures and standard construction practices. No permits are needed. Services and materials for this technology are readily available.

Cost: The cost for air purification systems is low.

Screening: This technology may be useful for specific applications, such as in enclosed rooms with no supplied outside make-up air. This technology could be used as an add-on to another technology for limited use under specific conditions; however, it is not applicable as a remedial technology for an entire building.

6.6. List of Retained Technologies

After eliminating certain technologies as discussed above, the following technologies are retained for alternatives development:

1. No Action: No action would be taken to address vapor intrusion concerns.

2. Monitoring

3. Physical Barriers

   - Vapor barriers
   - Conduit sealants

4. Sub-Slab Pressure Control

   - Sub-slab (or membrane) passive ventilation
   - Sub-slab pressurization;
   - Sub-slab depressurization; and
   - Sub-membrane depressurization

5. Point-of-Exposure Measures:

   - HVAC Systems; and
   - Air purification.

7. DEVELOPMENT AND DETAILED ANALYSES OF REMEDIAL ALTERNATIVES

Remedial alternatives are developed as one of or a combination of some of the remedial technologies listed in Section 6.6. One alternative will not fit all buildings. The Supplemental FS presents alternatives that can be used for different building scenarios.

7.1. Development of Alternatives

The remedial technologies remaining after the initial screening have been assembled into logical remedial alternatives by applying engineering judgment. It is necessary to apply engineering judgment to develop remedial alternatives that are complete, feasible, logical, and capable of effectively addressing the vapor intrusion pathway for existing and future commercial and residential structures at the Site. Consistent with the EPA Supplemental RI/FS guidance, the "No Action" alternative is considered to provide a baseline against which the performance of other alternatives can be compared.

Several technologies used to address the vapor intrusion pathway are stand-alone alternatives and do not need to be combined with other technologies. From the initial screening of technologies in the previous chapter, the following remedial alternatives have been developed:

- Alternative 1: No Action
- Alternative 2: Monitoring
- Alternative 3: HVAC System
- Alternative 4: Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)
- Alternative 5A: Sub-Slab Depressurization
- Alternative 5B: Sub-Membrane Depressurization
- Alternative 6: Sub-Slab Pressurization with Vapor Barrier;

Table 7-1 lists the alternatives and their applicability to different building scenarios. This chapter provides detailed analyses of these alternatives. A summary of the analyses can be found in Table 7-2.

All of the alternatives also require evaluation of institutional controls (ICs). Screening and detailed evaluation of ICs are provided separately in Chapter 8 of this document.

7.2. Detailed Analysis of Alternatives

This section provides an evaluation of the remedial alternatives using seven evaluation criteria established by EPA (1988) and described in the Supplemental RI/FS work plan (Locus 2006a). These criteria are:

Overall protection of human health and the environment: This criterion provides a final check to assess whether the alternative is protective of human health and the environment. This evaluation will describe how potential risks from vapor intrusion are eliminated, reduced or controlled by the alternative.

Compliance with the ARARs: This criterion is used to evaluate whether each alternative meets Federal and State ARARs. The detailed analyses summarize which requirements are applicable or relevant and appropriate to the alternative, and how the alternative meets these requirements. Compliance with the types of ARARs is assessed: chemical-specific, location-specific and action-specific.

Long-term effectiveness and permanence: This criterion addresses the alternative's risks remaining after response objectives are met. The following two components are addressed for each alternative:

- The magnitude of residual risks remaining after conclusion of the remedial activity;
- The adequacy and reliability of controls used to manage these residual risks. This factor also addresses the long-term reliability of management controls for continued protection from residual risks.

Short-term effectiveness: This criterion addresses effects of the alternative during the construction and implementation phase until the objectives are met. Under this criterion, alternatives are evaluated with respect to their effects on human health and the environment during implementation of the removal or remedial action. The following factors are considered for each alternative:

- Protection of community health during the removal or remedial actions (e.g., risks that may result from implementation of the alternative);
- Protection of workers' health during the removal or remedial actions;
- The time until objectives are achieved; and
- Environmental impacts, if any (adverse impacts on the environment as a result of the activity and reliability of remedial measures in preventing or reducing the potential impacts)

Reduction of toxicity, mobility, or volume through treatment: This criterion assesses whether the alternative reduces principal threats, including the extent to which toxicity, mobility, or volume of hazardous substances is reduced either alone or in combination with other alternatives. The following factors are considered for each alternative:

- The treatment processes to be used and the materials to be treated;
- The amount of hazardous substances to be treated, if any;
- The estimated degree of expected reduction in toxicity, mobility, or volume;
- The degree to which the treatment is irreversible; and
- The type and quantity of treatment residuals expected to remain after treatment.

Implementability: This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required for its implementation. This criterion involves analysis of the following factors:

- Technical feasibility: This relates to the feasibility of constructing and operating the alternative, the reliability of the alternative, the ease of undertaking additional removal action, if any, and the ability to monitor the effectiveness of the remedy;
- Administrative feasibility: Examples are operating permits/approvals and access;

- Availability of services and materials: This includes the availability of personnel and technology; off-site treatment, storage and disposal capacity and services; and the availability of necessary services, equipment, materials, and specialists.

Cost: The cost criterion evaluates alternatives based on economic considerations, which primarily consist of cost estimates derived for each alternative. The cost estimates usually include capital and annual O&M costs. The 30 -year present worth costs for each alternative were developed based on the detailed technology cost estimates shown in Tables 6-1 and 6-2, and are summarized in Tables 7-3 and 7-4 for the commercial and residential scenarios, respectively. The costs shown are estimates, and their accuracy may be within -30 percent to +50 percent of the final project cost.

State and community acceptance: This criterion evaluates technical and administrative issues and concerns the State and the community may have regarding each alternative. This criterion is not addressed in this Supplemental FS because it will be addressed in the ROD amendment process after comments on the Proposed Plan are received.

7.2.1. Alternative 1: No Action

In this option, no action would be taken to address vapor intrusion concerns. Under applicable regulatory guidance, the no action alternative must be included in the detailed analysis. Inherent in the no action option is natural ventilation because all buildings experience, at a minimum, natural ventilation through open doors and windows. They may also leak through walls or other openings in the building structure.

Overall Protection of Human Health and Environment

If vapor intrusion results in indoor air concentrations exceeding long-term exposure goals, this alternative would not be protective of the human health and the environment.

Compliance with ARARs

If vapor intrusion results in concentrations higher than long-term exposure goals, this alternative would not reduce concentrations to below these goals. No other ARARs are applicable for this alternative.

Long-Term Effectiveness and Permanence

This alternative does not involve removal action. If vapor intrusion is found to cause concentrations higher than long-term exposure goals, this alternative is not effective.

Short-Term Effectiveness

Because no action is taken, this criterion does not apply.

Reduction of Toxicity, Mobility, or Volume through Treatment

The no action alternative does not reduce the toxicity, mobility, or volume of VOCs.

Implementability

This alternative can be implemented in new and existing commercial or residential developments.

No permits, long-term monitoring, or services would be required for this alternative. Demonstrating that vapor intrusion is not occurring may require characterization or sampling of the structure.

Cost

The costs for the no action alternative are essentially zero.

7.2.2. Alternative 2: Monitoring

Monitoring could be one or a combination of the following:

- Groundwater Monitoring: Trends in groundwater concentrations and water level measurements can be used to conclude whether the potential for vapor intrusion is increasing or decreasing. Definition of the plume boundaries would indicate if the Vapor Intrusion Study Area (Figure 2-1) should be modified.

- Air samples: Air samples provide empirical information on the concentrations of VOCs in the enclosed space. Vapor intrusion investigation at the Site included collection of approximately 2,800 indoor and outdoor air samples, which were used in defining conditions under which a building may need engineering controls to mitigate the vapor intrusion pathway.

- Soil gas and sub-slab soil gas samples: Several vapor intrusion guidance documents indicate soil gas and sub-slab soil gas samples as lines of evidence to evaluate the vapor intrusion pathway (ITRC 2007, Cal/EPA 2005, EPA 2002a). Sufficient soil gas samples collected spatially apart and at multiple depths to just above the water table may provide information to assess the potential vapor intrusion into a building. The vapor intrusion investigation at the Site included limited soil gas samples to evaluate the vapor intrusion pathway. Site-specific data and other lines of evidence would be necessary to screen out a property for vapor intrusion.

A monitoring plan will be developed after approval of the supplemental FS. The monitoring plan typically includes the following components i) sampling network, ii) analytical requirements, iii) sampling and monitoring schedule, iv) description of field activities, v) review process of results, vi) reporting requirements, vii) access notification provisions, and viii) QA/QC plans.

Overall Protection of Human Health and Environment

If vapor intrusion results in indoor air concentrations exceeding long-term exposure goals, this alternative would not be protective of the human health and the environment. However, if concentrations are below long-term exposure goals, monitoring can confirm the protection of human health. Conversely, if the concentrations are above long-term exposure goals, monitoring can be used to trigger the implementation of another alternative that would be protective. Monitoring could apply to areas or specific buildings over the plume where vapor intrusion has not been demonstrated to result in indoor air concentrations higher than long-term exposure goals.

Compliance with ARARs

If vapor intrusion results in concentrations higher than long-term exposure goals, this alternative would not reduce concentrations to below these goals. No other ARARs are applicable for this alternative.

Long-Term Effectiveness and Permanence

Long-term monitoring is used to evaluate changes in the potential for vapor intrusion. For example, trends in groundwater concentrations in an area can be used to evaluate if the potential for vapor intrusion is increasing or decreasing. Indoor air samples can be used to provide empirical data on concentrations of VOCs, and to confirm that concentrations remain below long-term exposure goals. Monitoring only (i.e., without engineering controls) is not effective for buildings where indoor air concentrations result in unacceptable health risks.

Groundwater sampling at the Site has been performed since the early 1980s. This sampling has demonstrated that groundwater concentrations at the Site are generally decreasing. Therefore, groundwater monitoring can be used a line of evidence to demonstrate that vapor intrusion is not resulting in concentrations exceeding the action levels.

The FS proposes several ICs to ensure proper implementation of this remedy, while minimizing disturbances to operations. More information on institutional controls (including administrative operations) can be found in Chapter 8.

Short-Term Effectiveness

Refer to the discussion above on the long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume through Treatment

Monitoring is not an active remedy; therefore this alternative does not reduce the toxicity, mobility, or volume of VOCs through treament.

Implementability

Monitoring is implementable in existing and in new commercial or residential buildings. It uses proven procedures and standard practices. Sufficient monitoring wells have been installed at the Site to evaluate the plume boundaries and the trends in concentrations. Therefore, groundwater monitoring can be achieved with the existing network and with no additional access requirements. Access will have to be obtained from building occupants to allow the collection of air or soil-gas samples.

It is not likely that additional monitoring wells will be installed to monitor the groundwater concentrations. Therefore, no permits are expected for groundwater sampling. However, if groundwater wells are installed, permits are obtained from the Santa Clara Valley Water District, and encroachment permits may be needed from the City of Mountain View if the wells are installed in the City right -of -way.

Air samples do not require permits. Collection of soil gas samples may require encroachment permits from the City of Mountain View if the samples are to be collected in the City's right -of -way.

Cost

Costs were developed for a typical 20,000-square-foot one-story commercial building. There are no capital costs associated with this alternative. The annual O&M cost may vary between $800 and $4K, and the estimated 30-year present worth may vary between $10K and $50K. O&M costs include sampling and reporting.

Costs were also developed for a typical 2,000-square-foot residence. Similar to a commercial setting, there are no capital costs associated with a residence. The annual O&M cost may vary from $300 to $1.5K and the 30-year present worth from $4K to $19K.

7.2.3. Alternative 3: HVAC System

Ventilation has historically been used to improve the indoor air quality in buildings. CARB specifies ventilation as a standard engineering approach to assuring good indoor air quality, and as one of five methods to improve it (CARB 2005). EPA documents also identify ventilation as means to prevent or correct indoor air quality. For example, an EPA document refers to increasing the outdoor make-up air to improve the air quality (EPA 1991). Mechanical ventilation is provided by HVAC systems that convey outdoor air into the building enclosure. The net effect is an air exchange rate, which is defined as the rate at which the volume of indoor air is exchanged/ replaced with outdoor air. For example, an air exchange rate of 1/hr means that the indoor air is replaced with outdoor air once each hour.

HVAC systems can induce positive pressure in some air-tight buildings. During the remedial investigation, indoor air samples were collected from various buildings including air-tight buildings that may experience positive pressure and from leaky buildings that, at a minimum, have neutral pressure with the outside. As mentioned in Section 6.5.5.2, air sample results demonstrate that commercial buildings with an air exchange rate of at least 1/hr generally showed TCE concentrations significantly lower than the action level for both air-tight buildings and leaky buildings.

As part of this alternative, all identified direct and leaking conduits that serve as a pathway for vapors from the subsurface to migrate into the building enclosure would be sealed prior to implementation of the system. In addition, air purifier units may be utilized as part of this Alternative as an add-on technology to address VOCs in enclosed rooms with no supplied outside make-up air.

Overall Protection of Human Health and Environment

This alternative is protective of human health and the environment in that VOC concentrations inside the building are reduced to protective levels. If the ventilation system is operated at a high enough level, it induces positive pressure in the building enclosure and thereby eliminates or significantly reduces the migration of VOCs into the building; otherwise it acts to dilute the concentration of VOCs that have entered the building. Air purifiers could be used in conjunction with the HVAC system, if needed, to remove VOCs from air inside unventilated, enclosed spaces that may be occasionally occupied.

Compliance with ARARs

This alternative has been demonstrated at the Site and complies with both long-term exposure goals and action-specific ARARs.

Long-Term Effectiveness and Permanence

By exchanging indoor air with outside air, VOCs are removed from the building enclosure. Sampling at the Site has demonstrated that buildings with an air exchange rate greater than or equal to 1/hr generally have TCE concentrations below long-term exposure goals, demonstrating the effectiveness. In addition, the supplemental RI report indicates that for those buildings when ventilation was off for an extended period of time (e.g., building was unoccupied), there is typically at least a 10-fold reduction in TCE indoor air concentrations when the ventilation system was operated.

HVAC systems can induce positive pressure in some air-tight buildings. Using positive pressure as the indication of proper ventilation, however, can be problematic for many reasons:

- Differential pressure measurements are taken across some form of barrier at two discreet locations. As a result, there will likely be a range of differential pressures within a given building – both positive and negative – depending on where the two discreet locations are positioned within the building.

- Pressure differentials vary with weather and ventilation system operations, so the values measured at a particular moment in time may not apply at other times.

- If there is a temperature differential between the inside of the building and the outside, the pressure differential through the exterior walls varies with height. Under heating conditions, air will flow into the building at lower elevations, but will flow out of the building at higher elevations. During the cooling season, the reverse occurs.

- Pressure differential across the building envelope is also caused by wind, with higher pressures on the windward side and lower pressures on the other sides. Wind-induced pressures vary over the building and depend on the wind speed, direction, and obstructions surrounding the building.

- There is a wide range of differential pressures within a building driven by construction and physical building characteristics: high-rise buildings experience temperature gradients that can affect differential pressures (stairwells vs. occupied spaces, upper floors vs. lower floors, etc.), restrooms, kitchen areas and other odor-generating environments are kept at a negative pressure to mitigate odor migration.

- Demonstrating positive pressure is not feasible in many types of buildings; in others, large quantities of air would be required to achieve a minimal positive pressure. For example, warehouses are not typically positively pressured. Leaky buildings (e.g., unsealed windows, "breathing" buildings, etc.) would require very large volumes of air to achieve positive pressure.

Therefore, indoor air concentrations and system operations would be monitored to measure the effectiveness of the remedy, rather than positive pressure.

Permanence can be demonstrated through inspections and maintenance of ventilation systems. The California State Energy Code and OSHA regulations provide operating requirements for commercial building HVAC operation. The California Code of Regulations contains several provisions regulating the construction, use, and maintenance of HVAC systems. CCR Title 24, Part 6, Subchapter 3, Section 121 (State Energy Code regulations implementing the state ventilation code) provides specifications for the construction of HVAC systems in new buildings. Such a system must be capable of providing an outdoor air rate no less than the larger of 0.15 cubic feet per minute (cfm) per square foot of a commercial building space or 15 cfm per person times the expected number of occupants. For a single story commercial building, Cal/EPA states that 0.15 cfm per square foot equates to approximately 1 air exchange per hour (Cal/EPA 2005).

In addition, OSHA regulations at Title 8 (CCR Title 8, Division 1, Chapter 4, Section 5142) require HVAC systems to be maintained and operated to provide at least the quantity of outdoor air required by the applicable State Building Standards Code in effect at the time the building permit was issued. Like the State Energy Code discussed above, the State Building Standards Code, CCR Title 24, Part 2, Chapter 12, Section 1202.2.1, requires that the HVAC systems in buildings occupied for business use must be capable of supplying a minimum of 15 cubic feet per minute of outside air per occupant in all portions of the building during such time as the building is occupied. Section 5142 of the OSHA regulations requires the HVAC system to be “operated continuously during working hours” except in certain limited circumstances and when employers can show that “the quantity of outdoor air supplied by non-mechanical means meets the outdoor air supply rate.” This section also provides that the HVAC system must be inspected “at least annually,” and any problems found during these inspections must be corrected within a reasonable time.

Ventilation should operate continuously if appropriate in light of hours of worker occupancy. For example, there are buildings at the Site with continuous work shifts (455 E. Middlefield Road and some NASA buildings), and the HVAC systems in these buildings operate continuously.

To ensure permanence and proper operation of the ventilation system, management controls would be used including verification of system operations, inspections, education, and survey of building owners/occupants. The FS proposes several ICs to ensure proper implementation of this remedy, while minimizing disturbances to operations. More information on institutional controls (including administrative operations) can be found in Chapter 8.

Short-Term Effectiveness

This alternative is protective of worker's health during construction. Standard HVAC construction procedures would be used. There are no additional risks to the environment during the implementation of this alternative.

Reduction of Toxicity, Mobility, or Volume through Treatment

If the HVAC system is operated at a high enough level, it would induce positive pressure in the building enclosure and thereby eliminate or significantly reduce the migration of VOCs into the building; otherwise it would act to remove VOCs that have entered the building by displacement through ventilation, thereby reducing the volume of VOCs in the building. HVAC systems do not require treatment; therefore, the toxicity of VOCs is not reduced.

Implementability

This alternative can be implemented in new and existing commercial or residential buildings; however, HVAC systems are not typically installed in residences. HVAC systems also are not typically installed in warehouses, which rely on natural ventilation through roll-up doors, on passive ventilation through wind-driven turbines in the ceiling, or on mechanical exhaust fans. This alternative utilizes proven procedures and standard construction practices.

However, implementability of this remedy is complicated by the fact that the HVAC systems are operated and maintained by the building owners/occupants rather than responsible parties. South of Highway 101, MEW Companies do not own the properties in the MEW Area. Several of the properties are occupied by companies with very restrictive security measures to ensure proprietary, product, and security controls. In addition, various operations in the buildings (e.g., computer labs, offices, kitchens) may require different operation modes of HVAC systems. Therefore, the HVAC system needs to be operated by the occupant, who is most knowledgeable of operational requirements. Obligations under OSHA and the State Energy Code, discussed above, support the implementability of this remedial alternative. The PRPs, however, would retain the responsibility to monitor the operation of HVAC systems and their effectiveness in meeting long-term exposure goals in indoor air.

The remedy would include additional monitoring of the system by the PRPs to ensure proper operations and to collect indoor air samples when necessary.

Most commercial buildings have HVAC systems, and if modifications are necessary, they are typically minor. Services and materials for this alternative are readily available.

Cost:

Costs for an HVAC system are developed for two scenarios: 1) retrofitting an existing functioning system to increase the ventilation rate, and 2) installation of a new HVAC system. The capital cost to retrofit an existing system may range between $3.5K and $5.5K, and the annual O&M between $1.3K and $5.5K. O&M costs would include sampling, reporting, inspection, and verification of operations. Energy costs for increasing ventilation rates on an already functioning HVAC system (considering existing State law requirements on construction and operation of HVAC systems, as cited above) are estimated to be insignificant, and are not included. The actual incremental energy cost may vary from building to building, due to differences in building and HVAC system types. The 30-year present worth is estimated to range between $21K and $79K.

To install a new HVAC system, the estimated capital cost for a 20,000 square-foot building is $140K, and the annual O&M cost may range between $1.3K and $5.5K. O&M costs would include sampling, reporting and maintenance. The 30-year present worth is estimated to range between $157K and $213K.

Costs are not estimated for a residential setting where this alternative is not considered to be applicable.

7.2.4. Alternative 4: Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)

This alternative would consist of a passive sub-slab (or sub-membrane) ventilation system and a vapor barrier. A passive ventilation system would include a gravel and/or sand layer with perforated pipe (or an equivalent vapor capture system such as LBI's Geo-Vent system). The vent risers typically end with a wind-driven turbine that generate a slight negative pressure in the subsurface, and induce flow from the subsurface to the outside. Alternatively, differential barometric pressures throughout the day can also create a pressure differential and enhance the airflow. This alternative contains no mechanical equipment. However, the passive ventilation system would be designed so that it can easily be converted to an active ventilation system if needed.

The vapor barrier comes in a variety of textures and densities, each one specific to different situations. Because geomembrane-type vapor barriers are generally easier to maintain than spray-on type, and because the different geomembrane types generally have similar performance, high-density polyethylene (HDPE) geomembrane liner is selected as the representative process type for the vapor barrier for this alternative. Selecting a representative process type simplifies the evaluation of alternatives; however, the actual type of vapor barrier selected during the remedial design phase may be different based on the specific building condition.

Overall Protection of Human Health and Environment

This alternative is protective of human health and the environment in that the passive system and the vapor barrier eliminate the vapor intrusion pathway.

Compliance with ARARs

This alternative has been demonstrated at the Site (Wescoat Housing Area) to comply with both long-term exposure goals and location- and action-specific ARARs.

Long-Term Effectiveness and Permanence

This alternative has historically been used to prevent migration of VOCs into buildings. Its effectiveness depends on the design and installation quality as well as on long-term maintenance. For example, future modifications to building structures should avoid puncturing the barrier. Vapors may also leak through improperly sealed seams around utility penetrations.

The effectiveness of this alternative has been demonstrated at the Site in a new development on Moffett Field in the Wescoat Housing Area. Indoor air samples collected from the new homes showed VOC concentrations below the long-term exposure goals.

By eliminating the vapor intrusion pathway, indoor air concentrations would be similar to outdoor air concentrations, and the risks would be similar to those of breathing outdoor air. This alternative is passive, and therefore it will be present as long as the structure is present. Modifications to the building should either not penetrate the vapor barrier or should allow for proper replacement and/or sealing of the barrier.

The FS proposes several ICs to ensure proper implementation of this remedy, while minimizing disturbances to operations. More information on institutional controls (including administrative operations) can be found in Chapter 8.

Short-Term Effectiveness

This alternative is protective of workers' health during construction. Standard construction procedures would be used. There are no additional risks or impacts on the environment during the implementation of this alternative.

<u>Reduction of Toxicity, Mobility, or Volume through Treatment</u>

Elimination of the vapor intrusion pathway would eliminate VOC migration from the subsurface into the building, reducing the mass of VOCs that may potentially migrate into a building enclosure. Because no treatment is required, this alternative does not reduce the toxicity of VOCs.

<u>Implementability</u>

This alternative can be implemented in new commercial or residential developments (unless the development is planned with a basement below the water table). It is reliable and utilizes proven procedures and standard construction practices.

This alternative is not practical for existing residential or commercial structures because of the difficulty of placing a venting layer under slabs of existing buildings. In addition, the vapor barrier can only be installed in new buildings.

Monitoring of this alternative can be performed by collecting indoor air samples. Only standard building permits would be required.

Services and materials for this alternative are readily available. Installation of vapor barriers requires specialized skills and licensed contractors.

<u>Cost</u>

Because this alternative is implementable in future buildings, costs were developed for future residential and commercial buildings only.

For a 20,000-square foot commercial buildings, the capital cost is estimated to range between $162K ($90K for the passive system + $72K for the HDPE membrane barrier) and $189K ($107K for the passive system + $82K for the HDPE membrane barrier). The annual O&M costs may vary from $800 to $4K and include sampling and reporting. The estimated 30-year present worth estimate ranges between $173K and $242K.

For a 2,000 square-foot residence, the capital cost may range between $23K ($14K for the passive system + $9K for the HDPE membrane barrier) and $26K ($16K for the passive system + $10K for the HDPE membrane barrier). The annual O&M costs may vary between $300 and $1.5K and include sampling and reporting. The estimated 30-year present worth ranges from $27K to $46K.

7.2.5. Alternative 5A: Sub-Slab Depressurization

A SSD system typically consists of a sub-slab sand/gravel layer with a piping system and blower. The system is operated to create a slight negative pressure under the building slab, inducing flow of soil gas into the pipe. This is performed by pulling soil gas from beneath the slab through a pipe and venting them into the atmosphere. Depending on the emission rate of VOCs, the routed air may require treatment. Should cracks be present in the building, the SSD induces a flow from the building into the lower pressure area under the slab. When operating, soil gases generally cannot flow from under the sub-slab into the building enclosure.

There are several ways to install an SSD system. For example, in existing buildings, SSD systems can be implemented by installing one or more holes in the slab, removing the soil in the hole to create a suction pit, and placing vertical suction pipes into the holes. These pipes can be manifolded and connected to a vacuum blower (or fan) that evacuates soil gas from the sub-slab area, thus creating the negative pressure zone under the slab. SSD systems installed under a commercial building may use larger blowers often requiring a separate 120 or 240 V AC circuit (ITRC 2007)~~.~~ For future buildings, instead of "holes" created in the sub-slab, soil gas could be withdrawn from a sand/gravel layer installed under the sub-slab. A differential pressure of 0.025-0.35 inches of water is generally sufficient to maintain downward pressure gradients from the building enclosure to the sub-slab (EPA~~,~~ 1993). Guidance is available for the design, sizing, construction, and testing of SSD systems (EPA 1993, ASTM 2002, MassDep 1995). These guidance~~s~~ were developed specifically for radon mitigation, but studies have shown that properly designed SSD systems are effective as a remedial measure for VOC vapor intrusion (e.g., Folkes & Kurz 2002).

As part of this alternative, all identified direct and leaking conduits that serve as a pathway for vapors from the subsurface to migrate into the building enclosure would be sealed prior to implementation of the system.

<u>Overall Protection of Human Health and Environment</u>

This alternative is protective of human health and the environment in that VOCs are removed from the subsurface. The SSD system creates a negative pressure zone under the slab, which induces airflow into the pipes and away from the building enclosure. If the building has cracks, the air would move from the indoors, through the crack, and into the subsurface, mitigating vapor intrusion. Consequently, a SSD system reduces potential risks from vapor intrusion.

<u>Compliance with ARARs</u>

This alternative has been used at several sites in the nation, is well demonstrated in the field, and complies with both long-term exposure goals and action-specific ARARs. A BAAQMD permit may be required.

<u>Long-Term Effectiveness and Permanence</u>

A SSD system would remove chemicals from under the building slab. By creating a negative pressure zone under the building, the vapor intrusion pathway would be eliminated. Indoor air concentrations would be similar to outdoor air concentrations, and the risks would be similar to those of breathing outdoor air. It is anticipated that a SSD system would operate until the potential for vapor intrusion is reduced so that indoor air concentrations attributed to the vapor intrusion pathway are below long-term exposure goals. Premature shutdown of the SSD system may result in indoor air concentrations higher than EPA's long-term exposure goals.

SSD systems have been shown to be highly effective in controlling vapor intrusion in both new and existing structures. Sub-slab depressurization systems have also been shown in field applications nationwide to be effective for structures with basements.

The FS proposes several ICs to ensure proper implementation of this remedy, while minimizing disturbances to operations. More information on institutional controls (including administrative operations) can be found in Chapter 8.

Short-Term Effectiveness

This alternative is protective of workers' health during construction. Standard construction procedures would be used. There are no additional risks to the environment during the implementation of this alternative. Depending on emissions, exhaust air from the SSD system may have to be treated.

Reduction of Toxicity, Mobility, or Volume through Treatment

Although the purpose of a SSD system is to create a zone of negative pressure under the building and transport vapors away from the building enclosure, a SSD system also removes VOCs from beneath the slab. The induced negative pressure would result in vapor flow into pipes and away from the building enclosure, eliminating migration of VOCs into the building. Elimination of the vapor intrusion pathway would also reduce the mass of VOCs that potentially may migrate into a building enclosure. Unless treatment of the removed vapors is required, a SSD system does not necessarily reduce the toxicity of VOCs. If required, treatment may use technologies that collect and destroy VOCs.

Implementability

This alternative can be implemented in new commercial or residential developments. It is reliable and uses proven procedures and standard construction practices. SSD has been used nationwide to address the vapor intrusion pathway. This alternative can also be implemented at existing residential structures.

Implementability under large existing structures is limited because these systems may require multiple points of application (in comparison to one point for a single family home), trenching inside the buildings for pipes, and long disruptions to operations. Implementation in warehouses could be more feasible because warehouses typically have accessible open spaces that would allow for installation of multiple application points with associated pipes to the roof (e.g., along structural beams) or to the outside (by trenching through the warehouse floor). If horizontal piping is required, then existing foundations would prevent the pipes from being installed near the slab, which would reduce the effectiveness of the SSD system. This alternative cannot be implemented in structures with basements beneath the water table.

Monitoring of this alternative can be performed using one or a combination of the following: 1) pressure readings in the sub-slab area, 2) verification of blower operations, or 3) air samples in the building structure.

Depending on emissions, the BAAQMD may require a permit. Otherwise, only standard building permits would be required.

Services and materials for this alternative are readily available.

Cost

For a future 20,000-square-foot commercial building, the estimated capital cost may range between $103K and $123K. The annual O&M cost may vary from $7K to $12K and would include electrical costs, blower replacement after 10 and 20 years, and air sampling. The estimated 30-year present worth may range between $196K and $286K. For an existing commercial building, the capital cost is estimated to range between $133K and $221K. The annual O&M cost may vary from $9K to $13K. The 30-year present worth is estimated to range between $253K and $397K.

For a future 2,000-square-foot residence, the estimated capital cost may range between $18K and $21K. The annual O&M cost may vary from $800 to $2K and would include electrical costs, blower replacement after 10 and 20 years, and air sampling. The estimated 30-year present worth may range between $29K and $47K. For an existing residential building, the capital cost may range between $3K and $7K and the annual O&M cost is estimated to be $800 to $2K. O&M costs would include sampling, reporting, electrical costs, maintenance and blower replacement after 10 and 20 years. The 30-year present worth is estimated to range between $14K and $34K.

7.2.6. Alternative 5B: Sub-Membrane Depressurization

An SMD system typically consists of an impermeable membrane such as a cross-laminated polyethylene membrane, a plastic liner or a nonwoven geotextile fabric with a piping system and fan. The depressurization system collects soil gas from beneath the membrane and prevents vapor intrusion into the buildings. The membranes must be sealed along the edges of the foundation wall or footings and any pipe penetrations through the membrane. Air from the SMD is typically exhausted outside the building. When the air is drawn a vacuum is created beneath the membrane which flattens the membrane against the ground. Depending on the emission rate of VOCs, the routed air may require treatment.

As part of this alternative, all identified direct and leaking conduits that serve as a pathway for vapors from the subsurface to migrate into the building enclosure would be sealed prior to implementation of the system.

<u>Overall Protection of Human Health and Environment</u>

This alternative is protective of human health and the environment in that VOCs are removed from the subsurface. The SMD system lowers the sub-membrane air pressure relative to the crawlspace air pressure by use of a fan powered vent drawing air from beneath the membrane and induces the air flow into the pipe, and away from the building enclosure. Consequently, an SMD system reduces potential risks from vapor intrusion.

<u>Compliance with ARARs</u>

This alternative has been used at several sites in the nation, and compiles with both long-term exposure goals and action specific ARARs. A BAAQMD permit may be required.

<u>Long-Term Effectiveness and Permanence</u>

An SMD system would remove the chemicals potentially collected in soil gas beneath the crawlspace. The membrane typically covers all of the soil below the building floor, thereby blocking the vapor intrusion pathway. Indoor air concentrations would be similar to outdoor concentrations, and the risks would be similar to those of breathing outdoor air. It is anticipated that an SMD system would operate until the potential for vapor intrusion is reduced so that indoor air concentrations attributed to the vapor intrusion pathway are below long-term exposure goals. Premature shutdown of the SMD system may result in indoor air concentrations higher than EPA's long term exposure goals. The FS proposes several ICs to ensure proper implementation of this remedy, while minimizing disturbances to operations (see Chapter 8).

<u>Short-Term Effectiveness</u>

This alternative is protective of workers' health during construction. Standard construction procedures would be used. There are no additional risks to the environment during implementation of this alternative. Depending on emissions, exhaust air from the SMD system may have to be treated. Membranes need to be inspected and maintained regularly to prevent damages; which otherwise may result in high indoor air concentrations than EPA's long-term exposure goals.

Reduction of Toxicity, Mobility, or Volume through Treatment

An SMD system lowers the air pressure in soils below the crawlspace floor and transports vapors away from the building enclosure. This is accomplished by removing air from the soils, resulting in removal of VOCs from the subsurface. Elimination of the vapor intrusion pathway would also reduce the mass of VOCs that potentially may migrate into a building enclosure. Unless treatment of the removed vapors is required, a SMD system does not necessarily reduce the toxicity of VOCs. If required, treatment may use technologies that collect and destroy VOCs.

Implementability

This alternative can be implemented in future and existing residential developments with crawlspaces. It is reliable and uses proven procedures and standard construction practices. SMD has been used nationwide to address the vapor intrusion pathway. This alternative can also be used for future and existing commercial buildings with crawlspaces.

In the case of structures where the concrete footings divide the crawlspace, separate suction points are installed in each separate area between the footings. Where membranes are placed directly on low permeability soils, it may be necessary to consider extension of soil gas extraction pipe to more than one or more points below the membrane using either a perforated intake pipe or a manifold system with multiple suction points. Use of nonwoven geotextiles may also help extend the suction field of the system while protecting the membranes from the angular objects in the soil.

Accessibility to the crawlspace could limit the implementability of SMD. For example, sufficient headspace should be present to allow placement of the membrane in the crawlspace, and subsequent seating to footings, wells and pipes.

Depending on emissions, the BAAQMD may require a permit. Otherwise, only standard building permits would be required. Services and materials for this alternative are readily available.

Cost

For a new commercial construction, an estimated capital cost for a 20,000-square-foot building may range between $74K and $77K. The annual O&M cost may vary from $7K and $12K and would include electrical costs, blower replacement after 10 and 20 years, and air sampling. The estimated 30-year present worth is estimated to range between $167K and $239K. For an existing commercial building, the capital cost is estimated to range between $139K and $227K, the annual O&M cost between $9K and $13K, and the 30-year present worth between $259K and $403K.

For a 2,000-square-foot residence, the capital cost for a future residence may range between $14K and $15K. The annual O&M cost is estimated to be $800 to $2K and include blower replacement after 10 and 20 years. The 30-year present worth is estimated to range between $38K and $75K. For an existing residence, the capital cost may vary from $16K to $20K, and the O&M cost is $800. The 30-year present value is estimated to range between $40K and $80K.

7.2.7. Alternative 6: Sub-Slab Pressurization and Vapor Barrier

A SSP system introduces outside air to a layer of gravel and/or sand placed just beneath the building foundation. A small positive pressure builds in this layer by forcing outside air into the pore spaces. The pressurized layer eliminates convective flow of vapors from the underlying soils. The air that is pushed into the space under the slab moves across the gravel and leaves typically through exhaust vents that are located around the building boundary.

The vapor barrier would eliminate the potential for pressure-induced flow through openings in the slab. The vapor barrier comes in a variety of textures and densities, each one specific to different situations. Because geomembrane-type vapor barriers are generally easier to maintain than spray-on type, and because the different geomembrane types generally have similar performance, high-density polyethylene (HDPE) geomembrane liner is selected as the representative process type for the vapor barrier for this alternative. Selecting a representative process type simplifies the evaluation of alternatives; however, the actual type of vapor barrier selected during the remedial design phase may be different based on the specific building condition.

Overall Protection of Human Health and Environment

This alternative is protective of human health and the environment in that VOCs are removed from the subsurface. Air is injected from the outdoor to the sub-slab gravel/sand layer, travels horizontally through the layer, and exits through vents. The positive pressure may induce a downward flow of air through the subsurface formation, away from the building. This downward movement of air in the subsurface would prevent VOCs from migrating upward into the building.

If correctly installed during construction, the vapor barrier would eliminate the pressure-induced flow into openings in the slab such as seams around conduits and cracks.

Compliance with ARARs

This alternative is well demonstrated in the field and complies with both long-term exposure goals and location- and action-specific ARARs.

Long-Term Effectiveness and Permanence

Chemicals would be removed from the gravel/sand layer through introduction of outdoor air into the layer. Indoor air concentrations would be similar to outdoor air concentrations, and the risks would be similar to those of breathing outdoor air. It is anticipated that a SSP system would operate until the potential for vapor intrusion is reduced so that indoor air concentrations attributed to the vapor intrusion pathway are below long-term exposure goals. Modifications to the building should either not penetrate the vapor barrier, or allow for proper replacement and/or sealing of the vapor barrier.

SSP was used as a precautionary measure in a recent commercial development at the Site on 425-495 N. Whisman Road. Analytical testing showed that the VOC concentrations the sub-slab gravel annulus air were similar to outdoor air, demonstrating the effectiveness of this technology.

The FS proposes several ICs to ensure proper implementation of this remedy, while minimizing disturbances to operations. More information on institutional controls (including administrative operations) can be found in Chapter 8.

Short-Term Effectiveness

This alternative is protective of workers' health during construction. Standard construction procedures would be used. There are no additional risks to the environment during the implementation of this alternative. Exhaust air from the SSP system does not require treatment.

Reduction of Toxicity, Mobility, or Volume through Treatment

Induced positive pressure would result in downward vapor flow into the subsurface and away from the building slab, thus eliminating the migration of VOCs into buildings. Elimination of the vapor intrusion pathway would reduce the mass of VOCs that potentially may migrate into the building enclosure. Because no treatment is required, this alternative would not reduce the toxicity of VOCs.

Implementability

This alternative can be implemented in new commercial or residential developments (unless the development is planned with a basement below the water table). It is reliable and utilizes proven procedures and standard construction practices. SSP has been used nationwide to address the vapor intrusion pathway, and its implementability has been demonstrated at a recent commercial development at the Site.

This alternative is not practical for existing residential or commercial structures. Without the presence of a homogeneous gravel/sand layer, it is not possible to create an evenly distributed positive pressure zone under the buildings and short-circuiting is possible. In addition, the vapor barrier can only be installed in new construction.

Monitoring of this alternative can be performed using one or a combination of the following: 1) pressure readings in the sub-slab, 2) verification of blower operations, or 3) air samples in the sub-slab.

Only standard building permits would be required.

Services and materials for this alternative are readily available. Installation of synthetic vapor barriers requires specialized skills and licensed contractors.

Cost

Because this alternative is implementable in future buildings, costs were developed for future residential and commercial buildings only.

For a new commercial construction, the estimated capital cost for a 20,000-square-foot building may range between $176K ($103K for the pressurization system + $73K for the HDPE membrane barrier) and $206K ($123K for the pressurization system + $83K for the HDPE membrane barrier). The annual O&M costs may vary from $7K to $12K and include sampling, reporting, electrical costs, maintenance and blower replacement after 10 and 20 years. The estimated 30-year present worth is estimated to range from $269K to $368K.

For a 2,000-square-foot future residence, the capital cost may range from $28K ($18K for the pressurization system + $10K for the HDPE membrane barrier) to $32K ($21K for the pressurization system + $11K for the HDPE membrane barrier). The annual O&M cost is $800 to $2K and includes sampling, reporting, electrical costs, maintenance and blower replacement after 10 and 20 years. The estimated 30-year present worth ranges between $38K and $58K.

7.3. Comparative Analyses of Alternatives

This section evaluates the relative performance of each alternative in relation to each specific evaluation criterion. The purpose of this comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another.

Overall protection of human health and the environment and compliance with ARARs generally serve as threshold determinations and must be met by an alternative for it to be eligible for selection.

7.3.1. Overall Protection of Human Health and Environment

All of the alternatives, with the exception of Alternative 1 (No Action), would provide adequate protection of human health and the environment provided that they are implemented, operated, and maintained sufficiently. Alternative 2 (Monitoring) would only be protective if indoor air concentrations resulting from vapor intrusion are below long-term exposure goals, and monitoring of protectiveness through management controls was conducted. Alternative 1 would not eliminate, reduce, or control risk through any engineering and management controls, and would not be protective of human health and the environment; therefore it is eliminated from further consideration under the remaining criteria.

7.3.2. Compliance with ARARs

If vapor intrusion results in indoor air concentrations greater than long-term exposure goals, Alternative 2 (Monitoring) would not reduce concentrations to below these goals. All remaining alternatives would reduce concentrations to below these goals but would not meet their respective ARARs from Federal and State laws unless they were accompanied by appropriate institutional controls as discussed in Chapter 8.

7.3.3. Long-Term Effectiveness and Permanence

Alternative 4 (Sub-Slab Passive Ventilation with Vapor Barrier), Alternatives 5A/B (Sub-Slab/Membrane Depressurization), and Alternative 6 (Sub-Slab Pressurization with Vapor Barrier) all work to prevent the entry of VOCs into the building at levels exceeding long-term exposure goals. Indoor concentrations would be similar to outdoor air concentrations, and the risks would be similar to those of breathing outdoor air. Alternative 5A/B, in particular, has been demonstrated to be highly effective in controlling vapor intrusion in both new and existing structures. The long-term effectiveness and permanence of these remedies are dependent on proper operation and/or maintenance. Management controls for these "single-purpose" remedies are considered straightforward and reliable. However, Alternative 4, being a passive system, would also require that a periodic verification/monitoring program be in place to verify that the system continues to be effective.

Alternative 3 (HVAC System) can keep Site-related VOC concentrations in buildings under long-term exposure goals if the HVAC systems are property maintained and operated. However, because the HVAC systems would be operated by building owners/operators for the purpose of occupant comfort and to comply with the State regulations regarding construction and operations of HVAC systems rather than remediation, EPA does not consider management controls for this alternative to be as reliable as those of other alternatives. A periodic verification/monitoring program of the HVAC systems is an important part of the remedy to verify that the systems are operating according to specifications (see Chapter 8).

Alternative 2 (Monitoring) would have long-term effectiveness only where vapor intrusion has not resulted in indoor air concentrations exceeding acceptable risk levels.

7.3.4. Short-Term Effectiveness

All of the alternatives are protective of worker's health during construction, if any. Standard construction procedures would be implemented. There are no additional risks to the environment during the implementation of these alternatives.

7.3.5. Reduction of Toxicity, Mobility, or Volume through Treatment

Unlike typical remedial alternatives in the subsurface, remedial alternatives for the vapor intrusion pathway are not designed to reduce the toxicity of VOCs, and do not necessarily treat, with the exception of air purifiers, the VOCs present in the indoor space.

However, Alternative 4 (Sub-Slab Passive Ventilation with Vapor Barrier), Alternatives 5A/B (Sub-Slab/Membrane Depressurization), and Alternative 6 (Sub-Slab Pressurization with Vapor Barrier) all eliminate or significantly reduce the mobility of VOCs into the building.

Alternative 3 (HVAC System) reduces the volume of VOCs in the building. If the HVAC system is operated at a high enough level, it induces positive pressure in the building enclosure and thereby eliminates or significantly reduces the mobility of VOCs into the building; otherwise it acts to reduce the volume of VOCs that have already entered the building.

Alternative 2 (Monitoring) is not an active remedy, and therefore would not reduce the mobility or volume of VOCs.

7.3.6. Implementability

Alternative 2 (Monitoring) is easily implementable in all buildings. Alternative 3 (HVAC System) is generally implementable to existing and future commercial buildings. Alternatives 5A/B (Sub-Slab/Membrane Depressurization) are technically feasible in most buildings, but implementability in large existing structures may be difficult. Alternative 4 (Sub-Slab Passive Ventilation with Vapor Barrier) and Alternative 6 (Sub-Slab Pressurization with Vapor Barrier) are cost-prohibitive for existing buildings and therefore are considered feasible only for future buildings.

On the administrative side, implementing the ICs associated with Alternative 3 may be more complex than those of other alternatives, because the HVAC systems would be operated by building owners/occupants rather than by the responsible parties. This issue is discussed in more detail in Section 8.

7.3.7. Cost

Capital and O&M costs vary with each alternative and its application. The 30-year present worth costs of each applicable alternative are ranked below for commercial and residential buildings based on whether they are low, medium, or high.

Commercial Buildings

Low:

- Alternative 1: No Action
- Alternative 2: Monitoring
- Alternative 3: HVAC System (retrofit of existing systems)

Medium

- Alternative 3: HVAC System (installation of new HVAC system)
- Alternative 4: Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)

High

- Alternatives 5A/B: Sub-Slab/Membrane Depressurization
- Alternative 6: Sub-Slab Pressurization with Vapor Barrier

Residential Buildings

Low

- Alternative 1: No Action
- Alternative 2: Monitoring

Medium

- Alternative 4: Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)
- Alternatives 5A/B: Sub-Slab/Membrane Depressurization
- Alternative 6: Sub-Slab Pressurization with Vapor Barrier

Alternative 3 (HVAC System) is not considered applicable for residential buildings.

8. INSTITUTIONAL CONTROLS

Institutional controls (ICs) are an essential component of the remedial alternatives described in this Supplemental FS. ICs are non-engineered legal and administrative instruments that help to minimize the potential for human exposure to contamination and protect the integrity of a remedy. There are four categories of ICs: government controls, proprietary controls, enforcement tools with institutional control components, and informational devices. Each of these types of ICs can be used, alone or in combination, to ensure the protectiveness of an engineered remedy.

Government Controls

Government controls use the regulatory authority of a governmental entity to impose restrictions on citizens or property under its jurisdiction and typically include general and specific land use plans, zoning restrictions, ordinances, statutes, building permits, or other restrictions on land or resource use at a site (EPA 2000). Generally, EPA relies on state or local governments (such as a city or county) to establish these kinds of government controls. Once adopted, the local and state entities often use traditional police powers to enforce the controls. Because this type of IC is usually implemented by a local jurisdiction (such as a city or county), it may be changed or terminated with little notice to EPA, and EPA generally has no authority to enforce these controls.

Proprietary Controls

Proprietary controls are based on state property law and can be used to restrict or affect the use of a property. The most common proprietary controls are easements and covenants. These controls may involve recording legal instruments in the chain of title of the property and may be used to provide site access for O&M activities. These types of ICs are intended to be long-term or permanent as they can be binding on subsequent property owners and are transferable.

Enforcement Tools with IC Components

Enforcement tools include federal and state orders or decrees (e.g., 106 Orders, Consent Decrees) that are issued or negotiated to prohibit a party from using land in certain ways or from conducting certain activities at a property. These tools typically bind the original named parties and signatories and are enforceable by EPA or by the state if the state is a signatory or if state enforcement tools are used.

Informational Devices

Informational devices are tools used to provide information or notification about whether a remedy is operating as designed and/or notification to the public about contamination at a site. Examples include public notices, deed notices, fact sheets, and advisories. Because these informational devices do not compel an action, they are not typically a sufficient IC in and of themselves and are often used in conjunction with other types of ICs.

8.1. Objective, Mechanism, Timing, and Responsibility of ICs

ICs are response actions under CERCLA and are subject to the nine evaluation criteria discussed in Chapter 7 of this Supplemental FS. In accordance with EPA guidance (EPA 2000), the objective, mechanism, timing, and responsibility of an IC are determined before applying the evaluation criteria.

8.1.1. Objective

The objective of any IC is to ensure that the remedial alternatives are implemented and monitored properly to minimize the potential for human exposure to contamination. Here, the IC objectives will be to: (1) ensure that engineering controls used to prevent levels of indoor contaminants associated with the vapor intrusion pathway from reaching EPA's action level are operated and/or monitored as required by the remedy; and (2) ensure that the appropriate engineering controls are installed into any new development at the Site. Section 7 presents the remedial alternatives being considered for the vapor intrusion pathway. Some of the ICs proposed for this remedy may differ from traditional ICs. For example, one of the remedial alternatives for existing commercial buildings, HVAC system operation, is expected to be operated by the property owner, building owner, or building occupant, and not by the PRPs, although the PRPs will be responsible for implementing the remedy, including verifying that the building operator in fact operates the HVAC system adequately to meet long-term indoor air standards. This will require layered ICs to ensure that building owners, building operators, and the PRPs are appropriately involved with remedy implementation.

8.1.2. Mechanism

The types of ICs used to ensure proper operation of the remedial alternatives include government controls, proprietary controls, enforcement tools with IC components, and informational devices. Due to the large number of buildings and properties subject to this vapor intrusion remedy, successful implementation will require significant coordination to ensure that the remedy is operating as designed at each building and property. To coordinate the ICs, an Institutional Control Implementation Plan (ICIP) will be developed detailing the management, monitoring, and implementation of the ICs across the Site.

EPA, the City of Mountain View (City), the PRPs, and the property and building owners and occupants at the Site are working together to develop the necessary "layers" of ICs that will be most effective at the Site. IC layering means using different types of ICs at the same time or at different points in series to ensure short-term and long-term protectiveness of the remedy.

8.1.3. Timing

Several IC mechanisms for the proposed remedy are already in place, including zoning, local permits, state codes, and certain types of information devices. These pre-existing mechanisms will need to continue to be monitored and updated as necessary to ensure that they meet the remedy requirements. Other ICs will need to be implemented after the remedy is selected. This includes any municipal ordinances or proprietary controls that would need to be implemented. Additionally, some ICs will need to change as land uses and property owners change over time. The timing and implementation of ICs will be detailed in the ICIP.

8.1.4. Responsibility

Generally, the PRPs have the responsibility to implement ICs for this remedy. However, some remedial alternatives require several ICs (IC layers) that rely on both enforcement by other entities and cooperation by other parties. For example, enforcement of government controls in the area south of U.S. Highway 101, such as zoning and local permits, are the responsibility of the City, while access to and operation of HVAC systems will require cooperation by property and building owners and operators. On Moffett Field, NASA owns the land and enforces its own land use restrictions through its Master Plan (NASA 1994) and conditions in its construction permits, agreements, and leases.

8.2. Identification of Institutional Controls

The following ICs were identified and are discussed in detail in Section 8.3, below. The ICs ultimately selected are intended to be used concurrently and managed using the ICIP.

Government Controls

- Zoning and zoning overlays
- Municipal Ordinances
- Local Permits/State Codes

Proprietary Controls

- Covenants

Enforcement Tools

- Administrative Orders
- Consent Decrees

Informational Devices

- Recorded Notices
- Public Notices

Other Potential Controls

- Agreements between the MEW Companies and Property Owners and Operators

8.3. Detailed Analyses of ICs

This section provides an analysis of ICs using seven of the nine evaluation criteria from the National Contingency Plan (NCP). The other two evaluation criteria, state acceptance and community acceptance, will be evaluated in the ROD Amendment following public comment.

Protectiveness of Human Health and the Environment: This threshold criterion is used to assess whether the IC is protective of human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs): This second threshold criterion assesses whether an IC meets federal and state ARARs. For this remedy, EPA has determined that Title 22 of the

CCR, Section 67391.1 is an ARAR. This regulation provides for the placement of a land use covenant on properties where hazardous wastes, constituents, or substances "will remain at the property at levels which are not suitable for unrestricted use of the land." Section 67391.1 acknowledges that there may be circumstances where it is determined that placement of a land use covenant is not feasible, and, in those instances, other institutional control mechanisms may be used to ensure that future land use will be compatible with the level of hazardous substances left on the property.

Long-term Effectiveness and Permanence: This criterion assesses the reliability and effectiveness of ICs to minimize the potential for human exposure to contaminated indoor air from the vapor intrusion pathway. Specifically this criterion evaluates the remedy's effectiveness in light of property ownership and use changes, the size of the area to be managed, and the ability to monitor and enforce the remedy over the long-term.

Reduction of Toxicity, Mobility, or Volume through Treatment: ICs are not treatment measures; therefore, this criterion does not apply and is not considered in this analysis.

Short-term Effectiveness: This criterion evaluates impacts on human health and the environment during construction and implementation of the remedy in the near-term.

Implementability: This criterion evaluates the feasibility of actually implementing the IC. Administrative feasibility of an IC looks at coordination among offices and agencies and whether the entity responsible to implement the IC possesses the jurisdiction, authority, and willingness to establish, monitor, and enforce the IC. This factor also assesses how complex it may be to coordinate all parties necessary to enact the IC and whether all necessary parties are likely to participate.

Cost: This criterion is used to evaluate the estimated cost for implementing, monitoring, and enforcing these ICs. Costs may include expenses to ensure that remedial measures are implemented on an individual property as well as the legal fees and agency costs to monitor and enforce the ICs.

8.3.1. Local Government Controls: Zoning

Zoning is a common land use control restricting allowed land uses in certain areas. Traditionally, zoning is used as part of a remedy to restrict incompatible land use development (e.g., restricting a property to industrial land use after a cleanup is completed with residual contaminant levels not allowing for residential use). Here, because there are remedial alternatives available to address all land uses, there is no need to limit zoning within the Vapor Intrusion Study Area. However, zoning serves an important informational role for the remedy by providing property and building owners with information on the remedial requirements for residential and commercial properties. The zoning process can also be used to inform the PRPs and EPA of potential changes in land use in an area that would trigger the implementation of a different remedial alternative.

Currently, the MEW Area (area south of U.S. Highway 101) is primarily zoned for commercial and light industrial use with residential use allowed along the western portion of the VOC plume. The Moffett Field area (area north of U.S Highway 101 on Moffett Field) includes both commercial and residential building use overlying the shallow VOC groundwater plume. NASA manages most of the buildings and associated land use zones through its Development Plan (NASA 2002) and its Environmental Issues Management Plan (EIMP) (EKI 2005). NASA has zoned a portion of its commercial area for future residential development.

Zoning Overlays: A local government can designate an area requiring special treatment by creating a zoning overlay for a specified district designed to promote the general health, comfort, and welfare. Use of a zoning overlay within the MEW Area could help to ensure that new buildings are designed and constructed with engineering controls to mitigate the vapor intrusion pathway, and therefore protecting human health.

Overall Protection of Human Health and the Environment: If VOC contamination at the Site could not be prevented from entering residential buildings through the vapor intrusion pathway, zoning could be used to prevent residential development in these areas to ensure protection of human health.

This Supplemental FS analyzes remedial alternatives to address vapor intrusion for existing and future commercial and residential building scenarios. Changes in zoning would not mean that the selected remedial alternative would no longer be protective, but rather that the remedy as applied to that area may also change. For example, if in the commercial area where the high VOC concentrations are found in the groundwater is rezoned into residential use, the remedial alternative applicable to that property would have to be adapted to accommodate residential use.

Use of a zoning overlay within the MEW Site area could help to ensure that new buildings are constructed with preventive vapor intrusion measures incorporated into the building design therefore protecting human health.

Long-Term Effectiveness and Permanence: Zoning is not considered to be permanent. A city may change zoning designations without notifying EPA, and property owners can obtain variances from existing zoning designations.

Short-Term Effectiveness: Zoning alone would not be effective as an IC. However, zoning is an effective way of conveying information regarding the use designations of different areas within the Vapor Intrusion Study Area. Accordingly, this information can be used to determine which remedy requirements apply to each of those areas. If a new zoning designation was adopted in the future for an area, construction would need to comply with remedy requirements for that particular use designation and, therefore, would also be protective in the short term.

Implementability: The zoning IC is implementable because the vapor intrusion remedy will follow current and future zoning designations. However, regarding zoning overlays, the City of Mountain View staff has indicated that few such overlays exist in Mountain View and that enacting new overlays would be complex because the overlay would need to be approved by the affected property owners. Additionally, the City has raised the concern that, because there are other solvent plumes within the City boundaries, the City would need to address concerns regarding why an overlay was established in the MEW Site alone and not in other areas where vapor intrusion may also be an issue.

Cost: No capital costs are associated with this IC. The O&M costs would include the costs for periodic review of zoning with the City of Mountain View and NASA. The cost would likely range between $800 and $1.5K per year, with a 30-year present worth for O&M costs that may range between $10K and $19K. If the City should pursue the creation of an overlay zone at the MEW Site, future costs would be expected to include the cost to formulate the overlay, conduct community outreach, bring changes to the City Council for its approval, and possibly defend costs for potential legal challenges.

8.3.2. Local Government Controls: Local Permits/State Codes

This IC includes discretionary land use permits, building permits, and state codes that set forth specific requirements or provide for imposition of specific conditions, before an activity or construction can be authorized on a property. Examples of this IC include discretionary land use permit review and California Environmental Quality Act

(CEQA) review for proposed development projects, and commercial building codes for sub-slab systems and for raised foundations.

According to the City (City of Mountain View 2006), its current planning review and permitting process for new development and redevelopment includes the use of database tools, mapping tools, and staff expertise to assess impacts to groundwater and soils. The process in many instances also includes CEQA review.

To date, the City has been coordinating with EPA on an informal basis to use local government controls to implement mitigation measures in new building developments. This IC addresses new buildings or redevelopments or a change in use of existing buildings requiring discretionary approvals that trigger the CEQA process. The City has used its CEQA review process to address potential vapor intrusion issues by requiring preventive measures at new buildings and redeveloped properties. The City's CEQA procedure includes the following elements:

- Coordination with regulatory agencies (in the case of the MEW Site, EPA) to ensure that proper environmental documents are reviewed;
- Coordination among appropriate City departments;
- Hiring a consultant to review related environmental documents related to the Site, which would include the vapor intrusion ROD Amendment. The consultant reports to the City planning department;
- After the environmental review, the City planning department includes conditions on the permit approval, and coordinates with the City building department;
- The City building department develops a checklist of permit conditions prior to project approval, including environmental conditions, and ensures that the conditions are met. The developer annotates the conditions, how they have been met, and reports back to the building department.

Certain developments, most significantly single-family homes, are exempt from the CEQA process. For those developments, the City has indicated that it can use its other planning tools, including its Geographical Information System (GIS), to assess potential remedial requirements for given environmental conditions. For example, GIS can be used to superimpose TCE and other VOC groundwater plume maps from Site environmental reports and other agency websites over an existing parcel map to assess the relative locations of Site contaminants to a particular residential development or redevelopment location. These maps can guide the planning department in determining applicable development conditions for those parcels.

For new commercial buildings, the City relies on the California state mechanical and building codes, which may provide for HVAC systems capable of meeting the needs of the HVAC System alternative. However, after the initial inspection of the building to ensure that the systems installed are capable of meeting this requirement, the City does not verify HVAC system functionality on an ongoing basis.

<u>Overall Protection of Human Health and the Environment:</u> As described above, local government controls, the CEQA process, the City's building permitting process, and the use of City planning tools, assist in ensuring the protectiveness of human health for new construction and redevelopment.

The CEQA process, building permitting process, and use of current City planning tools help to ensure that the appropriate remedial systems are installed into new construction and development. HVAC systems installed in structures built since 1995 should meet standards and codes that are capable of functioning at levels that are protective of human health. On the other hand, HVAC systems in buildings built prior to 1995 may not be capable of meeting the requirements of the HVAC system remedial alternative. Therefore, in order for this IC to be effective, an HVAC system upgrade may be necessary.

However, these controls only ensure that buildings have HVAC systems capable of being utilized as remedial equipment. Where the remedy requires the use of a building's HVAC system, there are no local government controls in place currently to ensure the HVAC system continues to function to the extent necessary to reduce indoor air concentrations to meet the indoor air action levels. Typically, as a matter of current practices, the City only becomes involved with HVAC system monitoring or enforcement to ensure that reported violations are corrected. The City does not presently have the resources or staffing to implement an HVAC system monitoring and enforcement program.

For the reasons mentioned above, and to ensure overall protection of human health, this IC should be layered with others.

<u>Long-Term Effectiveness and Permanence:</u> Local permits and state codes, in particular CEQA review, can be effective tools in the long-term to help ensure that future buildings, through permits or conditions of approval, install remedial systems capable of meeting requirements of the vapor intrusion remedy. However, local permits and state codes do not address the ongoing operation of remedial equipment. Further, the City has stated that it is only involved with correction of reported HVAC system violations and does not presently have the jurisdiction, resources, or staffing to implement an on-going HVAC system monitoring and enforcement program. Finally, like zoning, local permitting and state codes can change without notice to EPA, and developers can obtain variances to these requirements on an individual basis. Ongoing monitoring would be required to ensure Site-wide implementation.

<u>Short-Term Effectiveness:</u> Currently, the City is working closely with the EPA informally to implement protective measures in new developments using the City's permitting process. Selection of an IC that codifies the vapor intrusion remedy will help ensure that the remedial requirements are met in the short term as well as the long term.

<u>Implementability:</u> During the development of the proposed vapor intrusion remedy, the City has been informally implementing measures to prevent vapor intrusion through permit requirements. The implementation of the vapor intrusion remedy would require a formal and enforceable mechanism, such as an ordinance or restrictive covenants, to ensure the ongoing protectiveness of the remedy. Following codification of these requirements, they should be easily implementable, as reflected in the current practices of the City. The ICIP will also identify methods to ensure this notification process continues effectively into the future.

<u>Cost:</u> Costs for this IC can be related to the certain components of the CEQA process related to the vapor intrusion pathway, such as risk assessments, environmental sample data, and reports associated with future developments or modifications to existing structures. These costs may vary between $20K and $35K per event. Assuming three new constructions every five years for the next 30 years that would undergo the CEQA process within the MEW Area, the 30-year present worth cost would range between $122K and $213K.

In addition to the costs above, monitoring of local and state permits can range between $1K and $1.5K per year, with a 30-year present worth ranging between $12K and $19K. The O&M cost includes monitoring of local/state codes related to specific remedial alternatives (e.g., HVAC system specifications, CEQA process, and City building permitting procedures).

8.3.3. Local Government Controls: Public Health and Safety Ordinances

A local government can adapt the regulatory agency's designation of an area requiring special treatment or place a requirement on property owners by amending and implementing those local health and safety ordinances designed to protect public health and safety (e.g., Hazardous Materials Permit Code). Examples include requiring vapor mitigation measures for newly constructed buildings at the MEW Area and requiring that commercial building owners operate their HVAC systems in compliance with the vapor intrusion remedy and be accessible for inspection, sampling, and remediation activities.

City staff has discussed the adoption of a health and safety ordinance to address both ongoing operation of HVAC systems in existing commercial buildings and appropriate construction of future buildings in accordance with the vapor intrusion remedy. As discussed in the previous section, to date, the requirements for future construction have been implemented informally through the City's permitting process. Codifying these requirements and adding the requirements for current property operation would necessarily involve a significant public decision-making process. City staff has also indicated that development, implementation, and enforcement of such an ordinance beyond the City's current involvement would exceed the current City staff and resources.

<u>Overall Protection of Human Health and the Environment:</u> A health and safety ordinance could be an effective part of a plan to protect human health at the Site. Because an ordinance can apply to the MEW Vapor Intrusion Study Area south of U.S. Highway 101, as an IC it could ensure that remedial alternatives are incorporated into the City permitting processes and all building owners and operators are aware of the remedial requirements. This could provide consistent protection of human health in the Site area.

<u>Long-Term Effectiveness and Permanence:</u> A local ordinance is not considered a permanent IC because a City can revoke an ordinance without notice to EPA. While in effect, however, use of local public health and safety ordinances can be an effective long-term method to ensure remedy implementation. Any such ordinance would require ongoing monitoring and enforcement to ensure implementation.

<u>Short-Term Effectiveness:</u> If it were enacted and implemented, a City ordinance requiring operation of the vapor intrusion remedial measure for buildings in the Vapor Intrusion Study Area south of U.S. Highway 101, along with ongoing monitoring and enforcement, could be effective in the short term.

<u>Implementability:</u> California's Constitution grants to cities and counties the authority to "make and enforce within [their] limits all local, police, sanitary, and other ordinances and regulations not in conflict with general laws." (California Constitution, Article XI, §7) Thus, the City may exercise its police powers broadly regarding ordinances addressing the vapor intrusion pathway, but only in a manner that does not conflict with state law. The City has the authority to adopt a health and safety ordinance. However, the actual adoption of an ordinance would require several steps. The ordinance would have to be developed to satisfy the requirements of the remedy, and it would have to undergo City Council decision-making including public hearings prior to adoption. Some of the processes to be encompassed in the ordinance are already being conducted by the City, such as permit requirements, and the ordinance would simply codify those requirements. Other components, such as requiring use of HVAC systems to meet ROD requirements, would need to be developed and should be implementable with sufficient support.

<u>Cost:</u> This IC would be adopted through the municipal process for adoption of ordinances in the City, and would involve meetings, comments, responses to comments, public notices, and hearings. Once an ordinance is adopted,

there would be implementation costs which will vary depending on the scope of the ordinance. In addition, inspection, monitoring and review of compliance could be conducted by EPA and/or the MEW Companies. City involvement could be limited to enforcing compliance with the ordinance, as necessary. The MEW Companies estimate that the cost to prepare and adopt an ordinance is approximately $25K, and the annual cost to monitor and enforce the performance of the ordinance is approximately $23K similar to that of monitoring a covenant (See Section 8.3.4 below). The 30-year present worth cost is estimated to be $310K.

8.3.4. Proprietary Controls: Covenants

Proprietary controls include property use restrictions based on private property law, including easements and covenants. This type of control is advisable when restrictions on the property will be long-term or permanent, such as when contaminants will be left in place that prevent unrestricted use. A covenant that acts as a proprietary control is an agreement between one landowner and another to use or refrain from using the property in a certain manner. Restrictive covenants do not need to be between adjacent landowners, but rather for environmental purposes can be established under California law between the landowner and another party, and may include a third party beneficiary. Examples could be recorded agreements not to modify a building without installation of vapor mitigation measures such as a sub-slab depressurization system or compliance with a remedial O&M plan requiring that remedial systems on the property are operated in a manner to ensure compliance with the vapor intrusion remedy.

Agreements are only automatically binding on subsequent owners if they are recorded and thus run with the land. Therefore it is EPA's view that recorded covenants have a heightened level of enforceability (see California Civil Code Sections 1468 and 1471) when compared with non-recorded agreements. The General Services Administration, however, prohibits recording covenants on Federal properties; as a result, recorded covenants can not be adopted for the Moffett Field area of the Site.

The distinct advantage of having recorded covenants is that they run with the land and thus only need to be negotiated with one property owner. Thereafter, the requirements are in place for future owners. Additionally, EPA can act as a third party beneficiary of the recorded covenants and thus can directly conduct enforcement where property owners are not complying with remedial requirements.

On Moffett Field, NASA's EIMP provides a decision framework for the management of residual chemicals in soil and groundwater at NASA Research Park ("NRP") for new development. The EIMP provides a baseline of minimum design considerations for new construction, risk management measures to be implemented during construction at the NRP, post-construction risk management procedures for future subsurface activities, and procedures for long-term compliance with the EIMP. More specifically, the EIMP includes certain measures to be implemented in redevelopment to address the vapor intrusion pathway.

All NASA partners, tenants, project developers and other entities with responsibility at the NRP are obligated to: 1) review available information concerning environmental conditions; 2) determine the adequacy of the EIMP with respect to the expected Site conditions and the intended land use, as well as the conditions actually encountered during development; 3) establish management procedures to ensure that risk management measures are properly implemented and maintained; 4) comply with applicable policies, laws and regulations; and 5) evaluate the current understanding of the health effects of identified chemicals of concern. This process provides NASA with a decision framework to ensure protectiveness of human health; however, this decision framework will not result in the recording of a covenant, because covenants cannot be recorded on federal land.

<u>Overall Protection of Human Health and the Environment:</u> Properly executed and recorded agreements that spell out the specific conditions that are binding on subsequent owners are protective of human health.

<u>Long-Term Effectiveness and Permanence:</u> Recorded agreements run with the land and are binding on subsequent property owners and would be permanent unless specifically revoked. The recorded agreement language must be general enough to apply to future conditions and specific enough to bind future owners to those conditions. Over the long term, recorded agreements could be effective in informing future property owners of vapor intrusion issues and remedial requirements for each property.

<u>Short-Term Effectiveness:</u> This IC would be protective in the short-term when property transfers are taking place.

<u>Implementability:</u> Recorded covenants need to be negotiated with the current property owner and, because they run with the land, will apply to future owners. Obstacles to implementation of recorded covenants may include the number of properties involved here, the fact that they would be requested of third parties not currently affiliated with any of the named parties under the Consent Decree or CERCLA Section 106 Order for the MEW Area, and the likelihood of resistance from at least some property owners to recording such requirements on their title. There are approximately 60 separate properties within the MEW Area south of U.S. Highway 101. Negotiation of recorded covenants with the owners of each of the 60 properties could prove to be time-consuming and difficult.

Although asking property owners for recorded covenants will meet with more resistance than merely entering into unrecorded agreements, the level of permanence surpasses agreements that must be renegotiated with each successive owner.

<u>Cost:</u> For these covenants there are transactional costs for negotiating the agreements, costs for obtaining agreements from property owners, and the costs to record the restrictive covenants. The MEW Companies have estimated the cost of recording covenants on the existing buildings to range from $70K to $248K per building for 60 buildings, resulting in a total from $4.2M to $14.9M. This estimate may not include additional costs associated with and arising from potential litigation. EPA has estimated that the costs to record restrictive covenants would be between $10K and $35K per property, depending upon the complexity of the covenant's requirements. There are no additional initial costs expected for this IC on Moffett Field, because most VI-related work would be performed under NASA's EIMP.

Annual O&M costs associated with this IC include site-wide monitoring of the covenants, including notifications of owner/tenant change and building modifications. O&M costs could also include third party monitoring of property transactions (such as monitoring of Santa Clara County on-line records for property transactions). The annual O&M cost is estimated to be approximately $23K, with a 30-year present-worth value of $285K.

8.3.5. Enforcement Tools (with IC Components): Administrative Orders and Consent Decrees

EPA guidance describes that ICs can be implemented through enforcement mechanisms (e.g., orders and agreements. EPA already utilizes three enforcement mechanisms at the Site: a Unilateral Administrative Order (106 Order); a Consent Decree (CD), and a Federal Facility Agreement (FFA). However none of the signatories to these enforcement mechanisms own property at the Site. Therefore, amendments or modifications to these enforcement mechanisms would not be used to directly bind property owners to any affirmative duties regarding the remedy. Rather, EPA has indicated that these enforcement mechanisms would be used to require that the MEW Parties (i.e., the Parties named in the 106 Order and CD) ensure that property owners fulfill their affirmative duties regarding the remedy. This IC would not be used alone but would be used along with other mechanisms to ensure that the property owners are bound to conduct the remedial activities.

Overall Protection of Human Health and the Environment: This IC could be part of an ICIP that could be protective of human health to the extent that it provides for an – albeit indirect – enforcement mechanism to ensure that the affirmative duties regarding the remedy are being carried out.

Long-Term Effectiveness and Permanence: Consent Decrees are generally binding on not only their signatories, but also their successors, assignors, contractors and consultants. Orders are binding on all respondents named in an Order and can be amended to add additional respondents. Consent Decrees and Orders generally only terminate after written certification by EPA that all work has been completed at the Site, in accordance with the ROD.

Short-Term Effectiveness: The same criteria that support the long-term effectiveness of this IC also support its short-term effectiveness.

Implementability: These enforcement mechanisms are already utilized at the Site, indicating that any modifications or amendments to these mechanisms would be implementable as well. Consent Decrees require negotiation between EPA and the MEW Companies and are submitted to a court by the Department of Justice, whereas 106 Orders are developed and issued administratively by EPA.

Cost: The costs associated with developing a Consent Decree include negotiating, drafting, and filing the Consent Decree. The costs associated with developing and issuing an Order include drafting the Order.

8.3.6. Informational Devices: Recorded Notices

Recorded notices are informational documents recorded against a parcel of land and filed in public land records that can alert those searching the records to important informational notices about the property. Primarily the PRPs, the property owners, and, potentially, EPA, and/or state or local agencies would implement this IC. EPA and the PRPs would collaborate on the language to be included in the recorded notice that describes the risks and the measures that could be taken to minimize and manage the risks.

Overall Protection of Human Health and the Environment: This IC could be part of an ICIP that could be protective of human health to the extent that it provides alerts for subsequent owners to environmental conditions and potentially informs them of actions to minimize the risk from vapor intrusion. However, such notices are not always effective, as they do not always show up in title searches; therefore new owners may not be aware of them. Additionally, because the notices are on the deed, building operators would not be provided notice through this mechanism.

Long-Term Effectiveness and Permanence: Recorded notices may encourage appropriate land use. A recorded notice could alert a prospective owner about the vapor intrusion pathway, the remedy in place, and who to contact to discuss potential impacts for future development. Recorded notices are permanent as they are in the deed, but may not be effective in the long term because they may not be consistently provided during property transfers. Additionally these are notices that do not bind owners to any affirmative duties regarding the remedy.

Short-Term Effectiveness: The same criteria that support the long-term effectiveness of this IC also apply to its short-term effectiveness.

Implementability: This type of IC may be difficult to implement because property owners must agree to place these notices into their property records. Also, the format of the deed notice must be tailored specifically to what is allowable by the County. Additionally, if the effort were made to post a notice on the deeds, it may be more worthwhile to enter into a covenant with the property owner to require compliance with the O&M of the remedy instead of only an informational notice.

Cost: The MEW Companies estimate the cost to record a deed notice to range between $15K and $25K. Therefore, to record notices on approximately 60 properties would cost between $0.9M and $1.9M. This does not include the cost of negotiating with individual property owners for the permission to record the deed notice.

8.3.7. Informational Devices: Public Notices

Public notices come in a variety of forms. One example, fact sheets, can provide notice to potential users of land of potential risks with the land. Fact sheets could be available in the City's public library or other facilities (e.g., the building department) to describe the vapor intrusion remedy and provide contact information for the public to get more information. Fact sheets could also be mailed to a list of owners and tenants of buildings in the Vapor Intrusion Study Area identifying potential risks from vapor intrusion and activities that can be performed to minimize these risks. For a mailing list, the list of owners and tenants in buildings would need to be updated on an ongoing basis in order to ensure that any new owner or occupant is provided the information in a timely manner.

Information flow from notices can move in both directions -- from the PRPs and EPA to the public, and from the property owners and operators to the PRPs and EPA. For instance, individual notices to property owners or tenants may contain a short questionnaire to be completed by the property owner to provided updated information including any upcoming property transaction, changes in tenants, or planned modifications to buildings. Information on building modifications could be used to evaluate whether the modifications affect the integrity of the remedy, and, if so, the remedy can then be adjusted to accommodate those changes.

Overall Protection of Human Health and the Environment: A public notification IC, used as a part of the ICIP, can be protective of human health by alerting the public and those in control of buildings in the Vapor Intrusion Study Area about activities that can be performed to minimize the risk of VI. These notices can also appropriately alert the PRPs and EPA to changes in property ownership, building modifications, or other changes that may require adjustments to the remedy. Because these ICs are only informational, they should only be considered in conjunction with other ICs.

Long-Term Effectiveness and Permanence: Information mechanisms are not permanent and must be continually provided to be effective. Ownership, occupancy, and building uses will change over time. Therefore, a system must be in place to ensure that the public notices are provided to prospective and new owners and operators on an ongoing basis and that any new information about the property is provided to the PRPs and EPA.

Short-Term Effectiveness: The same criteria that support the long-term effectiveness of this IC also support its short-term effectiveness.

Implementability: This IC is implementable. Notices can be provided by the City or another governmental agency, or by the PRPs through mailings or at public meetings. For ongoing information gathering, there are services that can be used to provide information about changes in ownership and occupancy of buildings.

Cost: The cost of execution of this IC may be relatively low. These ICs may include preparation and mailing of public notices, public meetings, and monitoring of this IC. The estimated annual cost is approximately $9K with a 30-year present worth for O&M cost of $112K.

8.3.8. Other Potential Controls: Agreements between MEW Companies and Property Owners and Operators

While recorded access agreements and certain other unrecorded agreements between MEW Companies and property owners and operators do not fit easily into the four IC categories, if proven protective, these agreements could be used as one element in a "layered" approach under the ICIP to meet the ICs objectives.

There are a number of agreements between the MEW Companies and property owners that allow for accessing, monitoring, and, in some cases, installing and operating groundwater treatment systems. Nineteen of these twenty-five agreements have been recorded (i.e., they have been recorded in certain instances where the property in question was owned and subsequently sold by one of the PRPs). Although they are not as reliable and comprehensive as a restrictive covenant, recorded access agreements may be useful to provide notice to property owners that there are remedial requirements to be implemented at the property.

These recorded and unrecorded access agreements have provided for the necessary access and cooperation to implement the vapor intrusion investigation conducted thus far within the Vapor Intrusion Study Area, and the MEW Companies expect that the existing agreements will continue to be sufficient to support monitoring and verification of the operation of an HVAC system remedy for commercial buildings. Some of these existing agreements in the past, however, have been used primarily for access and to install the soil and groundwater remedial measures on a property, and these agreements would need to be revised. Further, none of the existing agreements expressly requires ongoing operation of the remediation systems at the levels necessary to meet the requirements of the vapor intrusion remedy. New agreements will be necessary for all or nearly all of the affected buildings to require implementation of the selected vapor intrusion remedy.

Additionally, because unrecorded agreements (i.e., agreements requiring implementation of the vapor intrusion remedy) would not run with the land, new agreements will be necessary for each new property owner, each time that the property is sold. Accordingly, there will be a need to be a vigorous program to ensure that the MEW Companies are informed of all property ownership changes and that all new owners are appropriately brought into the process to negotiate new agreements, whenever required.

Where the remedy is relying on ventilation through an HVAC system, agreements would be required specifying how the HVAC system must operate to be in compliance with ROD requirements on an ongoing basis for existing buildings. If monitoring indicates that the system is not operating at the required level on an ongoing basis, then an alternative approach may be required to ensure proper implementation of the remedy.

Overall Protection of Human Health and the Environment: Unrecorded agreements are not binding on subsequent owners; thus, they would need to be entered into with each new property owner. These agreements would not be enforceable by the MEW Companies against successors in interest. The level of overall protection of human health that these agreements could achieve would be highly dependent upon the strength of the mechanisms put in place to ensure that the MEW Companies are informed of any property ownership changes and that all new owners are appropriately brought into the process to negotiate new agreements. The agreements could require the owner/operator of the property to provide advance notice to the MEW Companies of any anticipated, proposed or pending change of title or interest in the property.

<u>Long-Term Effectiveness and Permanence:</u> The primary disadvantages of non-recorded agreements are that they are not permanent and they apply only to the current property owner. For this mechanism to be effective over the long-term, new property owners will need to be engaged in a timely manner. On properties where it would be feasible, recording these agreements so that they run with the land would improve their long-term effectiveness and permanence.

<u>Short-Term Effectiveness:</u> Where agreements are in place, this mechanism is effective in the short-term. However, consistent updating is required to ensure that each new owner is brought into the process in a timely manner.

<u>Implementability:</u> The management of agreements over the long term with each property owner, and potentially each building operator, is complex. Each individual building will have its own vapor intrusion remedy requirements, which could change over time. Depending upon the number of times a building changes owners, the complexity of maintaining individual agreements increases. Although the management of agreements will be resource-intensive, regardless of the ICs in place there likely will have to be agreements between each property owner and the MEW Companies in order to properly inform property owners of the vapor intrusion remedy requirements for each property and to establish access for monitoring.

While agreements can be obtained without federal, state, or local regulatory authority intervention, these agreements must provide for enforcement where compliance with the agreements is not forthcoming. For this reason, it may be advantageous for EPA and other regulatory authorities to be designated as third-party beneficiaries of these agreements for possible enforcement.

<u>Cost:</u> There are transactional costs for negotiating the agreements, costs for obtaining agreement from property owners, costs for monitoring agreements, and costs for enforcement of the agreements.

Similar to the cost assumptions for restrictive covenants, described above, the costs for each agreement will include initial contact, preparing an original document, meetings, making revisions, and execution of a final agreement document, but do not include the cost over the long term when changes in building use or ownership require new agreements to ensure proper implementation of the remedy, as the number and frequency of such changes are difficult to predict.

The MEW Parties estimate that for existing buildings, the capital costs for modifying existing environmental agreements for 23 buildings, with a total of 11 agreements (to account for multiple buildings with the same owner) is estimated to be in the range of $55K to $165K ($5K to $11K for each modification). In addition, the MEW Parties assume that they would need to negotiate 10 new agreements for a total ranging between $100K and $200K ($10K to $20K for each agreement). Therefore, the total capital cost for the first round of agreements could range from $155K to $365K. Whenever a property is sold, and each subsequent time the property is sold, an agreement with the new owner would need to be negotiated (unless otherwise determined to be binding), and the cost of negotiating that new agreement would be incurred.

Annual O&M costs associated with this IC include site-wide monitoring, including notifications of owner/tenant change and building modifications. O&M costs could also include third party monitoring of property transactions or monitoring of Santa Clara County on-line records for property transactions. The annual cost is estimated to be approximately $23K, with a present-worth value of $285K.

8.4. Monitoring of ICs

Because the vapor intrusion remedy will be IC-intensive, ongoing ICs monitoring will necessary the remedy over the long-term. The nature and intensity of monitoring will vary depending on which of the preceding approaches is selected for individual properties. Monitoring activities, schedules, and task responsibilities will need to be detailed in the ICIP, which will be incorporated into the O&M plan. The ICIP is expected to include ICs monitoring through each of the ICs mechanisms themselves. For overall monitoring, a system will be needed to track the remedy and applicable ICs for each property.

9. RECOMMENDED ALTERNATIVES

Chapters 7 and 8 developed and provided detailed analyses of remedial alternatives and institutional controls that would address the potential vapor intrusion pathway. This chapter provides recommendations for how these alternatives would be applied at the Site.

9.1. Application of Remedial Alternatives

EPA has established a tiering system applicable for the Vapor Intrusion Study Area for existing commercial and residential buildings, as well as for future developments, to evaluate and determine the appropriate level of action that would be required. This tiering system is based on indoor air concentrations of TCE. For existing commercial and residential buildings, the tiers and the corresponding proposed actions are shown in Table 9-1 below. EPA also developed a decision flowchart for existing buildings, provided as Figure 9-1.

Table 9-1
Tiering System for Existing Commercial and Residential Buildings

Tier	Description	Proposed Action
Tier 1	Buildings with indoor air concentrations ≥ the action level.	Implement Preferred Alternative to bring indoor air concentrations below the action level. Once achieved and confirmed, buildings would be recategorized as Tier 2.
Tier 2	Buildings with indoor air concentrations that are above outdoor (background)* concentrations but below the action level. Also former Tier 1 buildings that have been mitigated to below the action level.	If any engineered remedies are in place, continue operation and maintenance. -Implement monitoring and Institutional Controls.
Tier 3	Buildings overlying lower groundwater concentrations (i.e., TCE or PCE <100 µg/L for commercial areas and < 50 µg/L for residential areas; or vinyl chloride < 20 µg/L in commercial areas and < 10 µg/L in residential areas) and indoor air concentrations that are below/within outdoor (background)* concentrations.	Implement Institutional Control to notify future property and building owners of remedy requirements.
Tier 4	Buildings that can demonstrate through multiple lines of evidence that there is no longer the potential for vapor intrusion into the building at levels of concern.	After performance of all necessary confirmation sampling and documentation approved by EPA that all necessary action has been completed, then no action will be required.

* Outdoor concentrations of TCE typically range from below detection levels to 0.4 µg/m^3.

The assumption for existing buildings is that any building with concentrations below the action level that already has an engineered remedy or remedies in place (such as HVAC system or sub-slab passive ventilation with vapor barrier) would require continued operation and maintenance of that remedy in order to keep indoor air concentrations below the action level, unless proven otherwise.

For future commercial and residential buildings, the tiers and the corresponding proposed actions are shown in Table 9-2 below. EPA developed a decision flowchart for future buildings, provided as Figure 9-2.

Table 9-2
Tiering System for Future Commercial and Residential Buildings*

Tier	Description	Proposed Action
Tier A	Properties overlying higher groundwater concentrations (i.e., TCE or PCE >100µg/L for commercial areas and > 50 µg/L for residential areas; or vinyl chloride > 20 µg/L in commercial areas and > 10 µg/L in residential areas).	Implement Preferred Alternative 5A/5B. Perform confirmation indoor air sampling after building is constructed to confirm remedial action is effective.
Tier B	Properties overlying lower groundwater concentrations (i.e., TCE or PCE <100 µg/L for commercial areas and < 50 µg/L for residential areas; or vinyl chloride < 20 µg/L in commercial areas and < 10 µg/L in residential areas) and evidence indicates the potential for vapor intrusion into the building at levels of concern	Implement Preferred Alternative 4. Perform confirmation indoor air sampling after building is constructed to confirm remedial action is effective.
Tier C	Properties overlying lower groundwater concentrations (i.e., TCE or PCE <100 µg/L for commercial areas and < 50 µg/L for residential areas; or vinyl chloride < 20 µg/L in commercial areas and < 10 µg/L in residential areas) and where multiple lines of evidence indicate there is no longer the potential for vapor intrusion into the building at levels of concern.	Perform confirmation indoor air sampling after building is constructed to confirm that there is no potential vapor intrusion risk at levels of concern. If confirmed with EPA approval, then no action is required.

* Commercial or multi-family residential buildings constructed with aboveground raised foundations typically would be separated from the ground by a parking garage, which would allow adequate ventilation. Perform targeted confirmation air sampling after building is constructed to verify absence of preferred pathways into building.

9.2. Recommended Alternatives

Chapter 7 presented a detailed evaluation of alternatives. This section describes the recommended Alternative for each building scenario based on that evaluation. A summary of the recommended Alternatives is provided in Table 9-3. Institutional controls are necessary so that the selected remedies are implemented and monitored properly, as discussed in Chapter 8.

To determine the appropriate tier for each existing building (i.e., Tier 1, Tier 2, Tier 3, or Tier 4 defined in Table 9-1), each building will be evaluated using results from walk-throughs, interviews, inspections, and indoor air sampling. Once a building has been assigned a tier, the selected action for a building of that tier will be implemented, including engineering and institutional controls. Where multiple lines of evidence indicate that there is no potential for vapor intrusion above levels of concern, the building would be categorized as Tier 4, and no action would be required.

For future buildings, groundwater concentrations are first used to categorize the building as Tier A, B, or C (Table 9-2). If the building is proposed in an area where TCE or PCE concentrations in the groundwater are greater than 100 ug/L for a commercial setting and 50 ug/L for a residential setting, or where vinyl chloride concentrations in the groundwater are greater than 20 µg/L in commercial areas and 10 µg/L in residential areas, the building is categorized as a Tier A building, and the selected action for Tier A buildings will be implemented, including engineering and institutional controls. If the building is proposed in an area where TCE concentrations are less than those mentioned above, but evidence indicates there may be a potential for vapor intrusion above levels of concern, the building is categorized as a Tier B building, and the selected action for Tier B buildings will be implemented, including engineering and institutional controls. If the building is proposed in an area where TCE concentrations are less than those mentioned above, and multiple lines of evidence indicate there is no longer the potential for vapor intrusion into the building at levels of concern then sampling should be performed after the building is constructed to confirm there is no potential vapor intrusion risk at levels of concern. If confirmed with EPA approval, no action is required.

9.2.1. Existing Commercial Buildings

The alternatives applicable for existing commercial buildings are:

- Alternative 2: Monitoring
- Alternative 3: HVAC System
- Alternative 5A/B: Sub-Slab/Membrane Depressurization

Should engineering controls be necessary, the recommended alternative for existing commercial buildings with existing HVAC systems is Alternative 3: HVAC System. This alternative ranks high in technical Implementability, Overall Protection of Human Health and the Environment, and Cost. Although management controls to demonstrate Long-Term Effectiveness and Permanence for this alternative are not considered as reliable as those of other alternatives due to the fact that the remedial system would need be operated by building operators/occupants rather than the responsible parties, this alternative is recommended due to its performance against the other criteria.

Should engineering controls be necessary, the recommended alternative for existing commercial buildings without HVAC systems is Alternative 5A/B: Sub-Slab/Membrane Depressurization. Sub-Slab Depressurization is appropriate for buildings with slab on grade foundations, and Sub-Membrane Depressurization is appropriate for buildings with crawlspaces. For this building scenario, the significant cost advantage that Alternative 3 has for buildings with existing HVAC systems disappears, and Alternative 5A/B outperforms Alternative 3 on the balance of the other criteria.

9.2.2. Existing Residential Buildings

The alternatives applicable for existing residential buildings are:

- Alternative 2: Monitoring
- Alternative 5A/B: Sub-Slab/Membrane Depressurization

Should engineering controls be necessary, the recommended alternative for existing residential buildings is Alternative 5A/B: Sub-Slab/Membrane Depressurization. Sub-Slab Depressurization is appropriate for buildings with slab on grade foundations, and Sub-Membrane Depressurization is appropriate for buildings with crawlspaces. Of the applicable alternatives, Alternative 5A/B ranks highest in all criteria.

9.2.3. Future Commercial Buildings

The alternatives applicable for future commercial buildings are:

- Alternative 2: Monitoring
- Alternative 3: HVAC System
- Alternative 4: Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)
- Alternative 5A/B: Sub-Slab/Membrane Depressurization
- Alternative 6: Sub-Slab Pressurization with Vapor Barrier

The recommended alternative for future commercial buildings in Tier A overlying higher groundwater concentrations (TCE > 100 µg/L) is Alternative 5A/B: Sub-Slab/Membrane Depressurization. These areas are considered to have a higher likelihood of vapor intrusion issues, and therefore Alternative 5A/B is recommended based on long term effectiveness.

The recommended alternative for future commercial buildings in Tier B overlying lower groundwater concentrations (TCE < 100 µg/L) is Alternative 4: Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active). Although Alternative 5A/B is considered to have better long term effectiveness, these areas are considered to have a lower likelihood of vapor intrusion issues, and therefore Alternative 4 is recommended based on cost effectiveness.

9.2.4. Future Residential Buildings

The alternatives applicable for future residential buildings are:

- Alternative 2: Monitoring
- Alternative 4: Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)
- Alternative 5A/B: Sub-Slab/Membrane Depressurization
- Alternative 6: Sub-Slab Pressurization with Vapor Barrier

The recommended alternative for future residential buildings in Tier A overlying higher groundwater concentrations (TCE > 50 µg/L) is Alternative 5A/B: Sub-Slab/Membrane Depressurization. These areas are considered to have a higher likelihood of vapor intrusion issues, and therefore Alternative 5A/B is recommended based on long -term effectiveness.

The recommended alternative for future residential buildings in Tier B overlying lower groundwater concentrations (TCE < 50 µg/L) is Alternative 4: Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active). Although Alternative 5A/B is considered to have better long term effectiveness, these areas are considered to have a lower likelihood of vapor intrusion issues, and therefore Alternative 4 is recommended based on a slight cost advantage.

9.2.5. Limitations

The recommended alternatives discussed above are generally expected to be feasible most types of buildings at the Site. Given the various types of buildings, however, it is possible that the recommended alternative will not be feasible for some buildings. For example, the preferred alternative for an existing building without an HVAC system is Sub-Slab/Membrane Depressurization. However, this alternative is not feasible if the building has basement floor under the water table. In these cases, EPA will need to analyze one of the other remedial alternatives discussed in this FS, and determine whether that remedial alternative would be protective of human health, if implemented in the building at issue.

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TABLES

TABLE 6-1
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - COMMERCIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2)		City/Quan-Adjusted Price		Quantity	Total Cost		Assumptions/Comments
				Low	High	Low	High		Low	High	
Monitoring	**CAPITAL COSTS**			$0	$0	$0	$0		$0	$0	No capital costs associated with monitoring
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400	$2,000		$400	$2,000	Low: One event every 5yrs - high: One event every yr
	Reporting	Eng. Judgment	YR			$400	$2,000		$400	$2,000	
	TOTAL O&M							Total	$800	$4,000	
	PRESENT VALUE 30 YEARS							30-Yr PW	$9,822	$49,111	See Note 6 - Includes O&M costs
Sub-Slab Passive Ventilation - 20,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Plans, Design, Permits,CM	Eng. Judgment	LS			$15,000		1	$15,000	$15,000	Engineering, planning permitting
	Gravel/Sand Layer - Transport	MBC02315-490-1245/1255/1400	LCY	$6	$20	$7	$23	575	$4,012	$13,375	See Note 3, assumes 8-inch layer
	Gravel/Sand Layer - Install w/o Compaction	MBC02315-640-0050	LCY	$20	$32	$23	$37	575	$13,375	$21,399	
	Gravel/Sand Layer - Compact	MBC02315-0320-0700	ECY	$2		$2		500	$1,163	$1,163	8" thick
	Piping	MHC02620-250-2100	LF	$10		$12		2,600	$30,238	$30,238	Approx 20' OC
	Geotextile Filter Fabric	MHC02620-400-0100	SY	$2		$2		2,500	$5,815	$5,815	
	Roof Ventilator	MBC15850-800-1300	EA	$105		$122		25	$3,053	$3,053	3" Vents @ 20' 0c
	Ductwork	MBC15810-500-1500	LF	$4		$4		500	$2,035	$2,035	Single story - 20' @ each vent
	Finish Wall Around Duct	MBC09260-100-1200	SF	$12		$14		750	$10,467	$10,467	30 SF/vent. Increase unit price 3x for difficulty, painting
	Mobe/Demobe	Eng. Judgment	LS			$4,000		1	$4,000	$4,000	
	TOTAL CAPITAL COSTS							Total	$89,158	$106,545	Total Capital cost
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400	$2,000		$400	$2,000	Low: One event every 5yrs - high: One event every yı
	Reporting	Eng. Judgment	YR			$400	$2,000		$400	$2,000	
	TOTAL O&M							Total	$800	$4,000	
	PRESENT VALUE 30 YEARS							30-Yr PW	$99,780	$159,656	See Note 6 - Includes O&M and capital costs
Sub-Slab Pressurization - 20,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Same as passive venting - Add blower	See Above						See above	$89,158	$106,545	See total for Passive Venting
	Blower/Filter/Silencer/Guages	Vendor Quote	EA			$6,000	$9,000	1	$6,000	$9,000	
	Slab 6" Reinf	MER18-02-0321	SF	$5		$17		100	$1,745	$1,745	Increase unit price 3x for small quantity
	Security Fence	MER33-13-2306	LS	$609		$708		1	$708	$708	
	Electrical & Controls	Eng. Judgment	LS			$4,000		1	$4,000	$4,000	
	Mobe/Demobe	Eng. Judgment	LS			$1,500		1	$1,500	$1,500	
	TOTAL CAPITAL COSTS							Total	$103,111	$123,498	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400	$2,000		$400	$2,000	Low: One event every 5yrs - high: One event every yı
	Reporting	Eng. Judgment	YR			$400	$2,000		$400	$2,000	
	Electrical	Eng. Judgment	YR			$3,000	$3,000		$3,000	$3,000	Electrical costs
	Maintenance	Eng. Judgment	YR			$3,000	$5,000		$3,000	$5,000	Annual Maintenance of system
	Blower Replacement (averaged)	Eng. Judgment	YR			$167	$167		$167	$167	Replace blower @ yrs 10 and 20 $2,500 per replacement (costs is averaged for 30 years)
	TOTAL O&M		YR			$6,967	$12,167	Total	$6,967	$12,167	
	PRESENT VALUE 30 YEARS							30-Yr PW	$195,612	$285,043	See Note 6 - Includes O&M and capital costs

TABLE 6-1
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - COMMERCIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2)		City/Quan-Adjusted Price		Quantity	Total Cost		Assumptions/Comments
				Low	High	Low	High		Low	High	
Sub-Slab Depressurization - 20,000 SF Footprint											Costs applicable for new construction only
	Future Construction										
	CAPITAL COSTS	See Above						Total	$103,111	$123,498	
	O&M COSTS	See Above	YR			$6,967	$12,167	Total	$6,967	$12,167	Incl elec & replace blower @ years 10 & 20 - air sampling
	PRESENT VALUE 30 YEARS							30-Yr PW	$195,612	$285,043	See Note 6 - Includes O&M and capital costs
											Costs applicable for existing buildings
	Existing Construction (warehouse - no horizontal drilling)										
	CAPITAL COSTS										
	Depressurization Node & Piping	Eng. Judgment	EA			$3,500	$7,000	25	$87,500	$175,000	Nodes @ 30' OC. Incl conc work, permeable soil envelope, duct to roof. Assumes 1 story, envelope & duct adjacent to columns.
	Collection Trench (if Reqd)										
	Sawcut Concrete	MBC02220-360-0400/0420	LF	$4		$14		1,000	$13,956	$13,956	6" slab, 25 pipe runs @ 20'/run. Increase unit price 3x for multiple setups
	Concrete Removal & Disposal	Eng. Judgment	LS			$3,000		1	$3,000	$3,000	
	Buried Collection Piping	MHC02620-250-2110	LF			$9		500	$4,500	$4,500	25 pipe runs @ 20'/run
	Trenching & Backfill	MBC02315-620-0400	LF	$1		$7		500	$3,500	$3,500	Increase unit price 7x for small quantity, difficulty
	Backfill & Compact	MBC02315-620-1400	LF	$1		$7		500	$3,500	$3,500	Increase unit price 7x for small quantity, difficulty
	Slab 6" Reinf	MER18-02-0321	SF	$5		$35		500	$17,500	$17,500	Increase unit price 7x for small quantity, difficulty
	TOTAL CAPITAL COSTS							Total	$133,456	$220,956	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400	$2,000		$400	$2,000	Low: One event every 5yrs - high: One event every yr
	Reporting	Eng. Judgment	YR			$400	$2,000		$400	$2,000	
	Electrical	Eng. Judgment	YR			$3,000	$3,000		$3,000	$3,000	Electrical costs
	Maintenance	Eng. Judgment	YR			$5,000	$5,000		$5,000	$5,000	Annual Maintenance of system
	Blower Replacement (averaged)	Eng. Judgment	YR			$167	$1,250		$167	$1,250	Replace blower @ yrs 10 and 20 (Low: one blower @ $2,500/replacement - high: $750 per replacement, 25 blowers)
	TOTAL O&M		YR			$8,967	$13,250	Total	$8,967	$13,250	
	PRESENT VALUE 30 YEARS							30-Yr PW	$252,512	$396,885	See Note 6 - Includes O&M and capital costs

TABLE 6-1
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - COMMERCIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2)		City/Quan-Adjusted Price		Quantity	Total Cost		Assumptions/Comments
				Low	High	Low	High		Low	High	
Sub-Membrane Depressurization - 20,000 SF Footprint											Costs applicable for new construction only
	Future Construction (crawlspace)										
	CAPITAL COSTS										
	Plans, Design, Permits,CM	Eng. Judgment	LS			$15,000		1	$15,000	$15,000	Engineering, planning permitting
	Membrane materials & Installation	MBC07260-100-1200	SF	$0.18		$0.20		20,000	$4,082	$4,082	
	Blower/Filter/Silencer/Guages	Vendor Quote	EA			$6,000	$9,000	1	$6,000	$9,000	Nodes @ 30' OC. Incl conc work, permeable soil envelope, duct to roof.
	Security Fence	MER33-13-2306	LS	$609		$708		1	$708	$708	
	Electrical & Controls	Eng. Judgment	LS			$4,000		1	$4,000	$4,000	
	Piping	MHC02620-250-2100	LF	$10		$12		2,600	$30,238	$30,238	Approx 20' OC
	Ductwork	MBC15810-500-1500	LF	$4		$4		500	$2,035	$2,035	Single story - 20' @ each vent
	Finish Wall Around Duct	MBC09260-100-1200	SF	$12		$14		750	$10,467	$10,467	30 SF/vent. Increase unit price 3x for difficulty, painting
	Mobe/Demobe	Eng. Judgment	LS			$1,500		1	$1,500	$1,500	
	TOTAL CAPITAL COSTS							Total	$74,031	$77,031	Total Capital cost
	O&M COSTS	See O&M Costs for SSD Future Dev.	YR			$6,967	$12,167	Total	$6,967	$12,167	Same as SSD for future construction
	PRESENT VALUE 30 YEARS							30-Yr PW	$166,532	$238,576	See Note 6 - Includes O&M and capital costs
											Costs applicable for existing buildings
	Existing Construction (crawlspace)										
	CAPITAL COSTS										
	Depressurization Node	Eng. Judgment	EA			$3,500	$7,000	25	$87,500	$175,000	Nodes @ 30' OC. Incl conc work, permeable soil envelope, duct to roof. Assumes 1 story, envelope & duct adjacent to columns.
	Membrane materials & Installation	MBC07260-100-1200	SF	$0.18		$0.20		20,000	$4,082	$4,082	
	Security Fence	MER33-13-2306	LS	$609		$708		1	$708	$708	
	Electrical & Controls	Eng. Judgment	LS			$4,000		1	$4,000	$4,000	
	Piping	MHC02620-250-2100	LF	$10		$12		2,600	$30,238	$30,238	Approx 20' OC
	Ductwork	MBC15810-500-1500	LF	$4		$4		500	$2,035	$2,035	Single story - 20' @ each vent
	Finish Wall Around Duct	MBC09260-100-1200	SF	$12		$14		750	$10,467	$10,467	30 SF/vent. Increase unit price 3x for difficulty, painting
	TOTAL CAPITAL COSTS							Total	$139,031	$226,531	
	O&M COSTS	See O&M Costs for SSD Existing Bldg	YR			$8,967	$13,250	Total	$8,967	$13,250	Same as SSD for existing building
	PRESENT VALUE 30 YEARS							30-Yr PW	$258,087	$402,460	See Note 6 - Includes O&M and capital costs
Retrofit HVAC System (average per building)											Costs applicable for existing buildings
	CAPITAL COSTS										
	Add Dampers	Vendor Quote	EA			$500	$1,000	4	$2,000	$4,000	Assume an average of four package units per building
	Balancing	Vendor Quote	EA			$1,500	$1,500	1	$1,500	$1,500	Measurement of air exchange rate
	TOTAL CAPITAL COSTS							Total	$3,500	$5,500	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400	$2,000		$400	$2,000	Low: One event every 5yrs - high: One event every yı
	Reporting	Eng. Judgment	YR			$400	$2,000		$400	$2,000	
	Verification of Operations	Eng. Judgment	YR			$500	$1,500		$500	$1,500	
	TOTAL O&M	Eng. Judgment	YR			$1,300	$5,500	Total	$1,300	$5,500	
	PRESENT VALUE 30 YEARS							30-Yr PW	$20,761	$78,527	See Note 6 - Includes O&M and capital costs

TABLE 6-1
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - COMMERCIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2) Low	Price (Note 2) High	City/Quan-Adjusted Price Low	City/Quan-Adjusted Price High	Quantity	Total Cost Low	Total Cost High	Assumptions/Comments
New HVAC System (average per 20,000 SF)											Costs applicable for new or existing buildings
	CAPITAL COSTS										
	Design and Installation of New System	Eng. Judgment	EA	$120,000		$139,560		1	$139,560	$139,560	Cost for an average building. 2 units @ $60K each
	TOTAL CAPITAL COSTS							Total	$139,560	$139,560	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400	$2,000		$400	$2,000	Low: One event every 5yrs - high: One event every yr
	Reporting	Eng. Judgment	YR			$400	$2,000		$400	$2,000	
	Maintenance	Eng. Judgment	YR			$500	$1,500		$500	$1,500	
	TOTAL O&M	Eng. Judgment	YR			$1,300	$5,500	Total	$1,300	$5,500	
	PRESENT VALUE 30 YEARS								$156,821	$212,587	See Note 6 - Includes O&M and capital costs
Exhaust of Indoor Air											Costs applicable for new or existing buildings
	CAPITAL COSTS										
	Bathroom Exhaust - 50 cfm	MBC15830-100-6660	EA	$83		$97		1	$97	$97	Cost varies based on size of exhaust fan
	Roof Jack	MBC15830-100-6960	EA	$61		$71		1	$71	$71	
	Duct	MBC15810-500-1500	LF	$4		$4		12	$49	$4	
	Installation	Eng. Judgment	LS			$500	$1,000	1	$500	$1,000	
	Wiring	Eng. Judgment	LS			$100	$300	1	$100	$300	
	TOTAL CAPITAL COSTS							Total	$816	$1,472	
	O&M COSTS										
	Electrical	Eng. Judgment	YR			$500	$500		$500	$500	One exhaust fan
	Maintenance	Eng. Judgment	YR			$33	$33		$33	$33	Average annual cost for changing fan in years 10 and 20 ($1000/30 years)
	TOTAL O&M					$533	$533	Total	$533	$533	
	PRESENT VALUE 30 YEARS								$7,898	$8,553	See Note 6 - Includes O&M and capital costs
											Costs applicable for new or existing buildings
	CAPITAL COSTS										
	Kitchen Exhaust - 160 cfm	MBC15830-100-6900	EA	$125		$145		1	$145	$145	Cost varies based on size of exhaust fan
	Roof Jack	MBC15830-100-6960	EA	$61		$71		1	$71	$71	
	Duct	MBC15810-500-1500	LF	$4		$4		12	$49	$49	
	Installation	Eng. Judgment	LS			$500	$1,000	1	$500	$1,000	
	Wiring	Eng. Judgment	LS			$100	$300	1	$100	$300	
	TOTAL CAPITAL COSTS							Total	$865	$1,565	
	O&M COSTS										
	Electrical	Eng. Judgment	YR			$1,600	$1,600		$1,600	$1,600	One exhaust fan
	Maintenance	Eng. Judgment	YR			$67	$67		$67	$67	Average annual cost for changing fan in years 10 and 20 ($2000/30 years)
	TOTAL O&M					$1,667	$1,667	Total	$1,667	$1,667	
	PRESENT VALUE 30 YEARS								$22,995	$23,695	See Note 6 - Includes O&M and capital costs

TABLE 6-1
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - COMMERCIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2) Low	Price (Note 2) High	City/Quan-Adjusted Price Low	City/Quan-Adjusted Price High	Quantity	Total Cost Low	Total Cost High	Assumptions/Comments
Air Purification (Cost per Unit)											Costs applicable for new or existing buildings
	CAPITAL COSTS										
	Air Purification Unit (blower/carbon vessel)	Vendor Quote	EA			$3,200		1	$3,200		
	TOTAL CAPITAL COSTS							Total	$3,200		
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$500			$500		Air sampling (one sample per year)
	Reporting	Eng. Judgment	YR			$250			$250		One annual report to EPA
	Maintenance	Eng. Judgment	YR			$500			$500		Replace carbon every 3 years ($300/year). Replace unit @ years 10 & 20 ($3,200/replacement)
	TOTAL O&M	Eng. Judgment	YR			$1,250		Total	$1,250		
	PRESENT VALUE 30 YEARS							30-Yr PW	$19,797		See Note 6 - Includes O&M and capital costs
Modified-Soil Vapor Barriers - New Bldg - 20,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	12" Soil-Bentonite Liner - 6" Lifts	MER33-08-0505	SF	$1		$2		20,000	$32,564		Assume cost sim to PVC
	Mobe/Demobe	Eng. Judgment	LS			$5,000		1	$5,000		
	TOTAL CAPITAL COSTS							Total	$37,564		
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400			$400		Air sampling
	Reporting	Eng. Judgment	YR			$400			$400		
	TOTAL O&M	Eng. Judgment	YR					Total	$800		See Note 6 - Includes O&M and capital costs
	PRESENT VALUE 30 YEARS							30-Yr PW	$48,186		See Note 6 - Includes O&M and capital costs
HDPE Membrane Barrier - New Bldg - 20,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Liner Matl & Installation	MBC07100-200-2700	SF	$2		$3		20,000	$60,000	$60,000	
	Sand Blanket - 4" Lower, 4" Upper - Matl Only	MBC02315-490-1245/1255/1400	LCY	$6	$20	$7	$23	600	$4,187	$13,956	See Note 3
	Backfill & Compaction	MBC02315-110-1600	ECY	$3		$12		500	$6,210	$6,210	Increase unit price 4x for small quantity, difficulty
	Mobe/Demobe	Eng. Judgment	LS			$2,000		1	$2,000	$2,000	
	TOTAL CAPITAL COSTS							Total	$72,397	$82,166	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400	$2,000		$400	$2,000	Low: One event every 5yrs - high: One event every yı
	Reporting	Eng. Judgment	YR			$400	$2,000		$400	$2,000	
	TOTAL O&M	Eng. Judgment	YR			$800	$4,000	Total	$800	$4,000	
	PRESENT VALUE 30 YEARS							30-Yr PW	$83,019	$135,277	See Note 6 - Includes O&M and capital costs

TABLE 6-1
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - COMMERCIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2) Low	Price (Note 2) High	City/Quan-Adjusted Price Low	City/Quan-Adjusted Price High	Quantity	Total Cost Low	Total Cost High	Assumptions/Comments
Synthetic Barrier (Spray-Applied)											Costs applicable for new construction only
	CAPITAL COSTS										
	Liquid Boot ®	Vendor Quote	SF			$4	$6	20,000	$80,000	$120,000	
	TOTAL CAPITAL COSTS							Total	$80,000	$120,000	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400	$2,000		$400	$2,000	Low: One event every 5yrs - high: One event every yı
	Reporting	Eng. Judgment	YR			$400	$2,000		$400	$2,000	
	TOTAL O&M	Eng. Judgment	YR			$800	$4,000	Total	$800	$4,000	
	PRESENT VALUE 30 YEARS							30-Yr PW	$90,622	$173,111	see Note 6 - includes O&M and capital costs
Modified On-Grade Foundation - 20,000 SF Footprint - Additional to Std 4" slab-on-grade											Costs applicable for new construction only
	CAPITAL COSTS										
	Thickened Slab (4")	MBC03310-240-4700	CY	$165		$192		250	$47,974		8" Thick slab (4" additional concrete)
	TOTAL CAPITAL COSTS							Total	$47,974		
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400			$400		Air sampling
	Reporting	Eng. Judgment	YR			$400			$400		Annual report to EPA
	TOTAL O&M	Eng. Judgment	YR			$800		Total	$800		
	PRESENT VALUE 30 YEARS							30-Yr PW	$58,596		See Note 6 - Includes O&M and capital costs
											Costs applicable for new construction only
	CAPITAL COSTS										
	Slab Post-Tensioned in Place	MBC03410-650-0100	CY	$1,000	$1,200	$1,163	$1,396	500	$581,500	$697,800	8" Thick slab
	Less Standard Construction (4" Slab)	MBC03310-240-4650	CY	$197		$229		250	-$57,278	-$57,278	4" Thick slab
	TOTAL CAPITAL COSTS							Total	$524,222	$640,522	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$400			$400	$400	Air sampling
	Reporting	Eng. Judgment	YR			$400			$400	$400	Annual report to EPA
	TOTAL O&M	Eng. Judgment	YR			$800		Total	$800	$800	
	PRESENT VALUE 30 YEARS							30-Yr PW	$534,844	$651,144	See Note 6 - Includes O&M and capital costs

TABLE 6-1
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - COMMERCIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2)		City/Quan-Adjusted Price		Quantity	Total Cost		Assumptions/Comments
				Low	High	Low	High		Low	High	
Penetration Sealants - 20,000 SF Footprint											Costs applicable for new or existing buildings
	CAPITAL COSTS										
	Expanding Foam - Penetrations	Eng. Judgment	EA			$250	$500	15	$3,750	$7,500	Depending on level of effort
	TOTAL CAPITAL COSTS							Total	$3,750	$7,500	
	O&M COSTS										
	Inspection	Eng. Judgment	YR			$150	$150		$150	$150	Annual inspection and resealing of one conduit per year
	Re-sealing of one conduit	Eng. Judgment	YR			$250	$500		$250	$500	
	TOTAL O&M					$400	$650	Total	$400	$650	
	PRESENT VALUE 30 YEARS							30-Yr PW	$9,061	$16,130	See Note 6 -includes O&M and capital cost
											Costs applicable for new construction only
	CAPITAL COSTS										
	Pourable Polyurethane - Concrete Joints	MBC03350-325-0380	LF	$2		$2		3,200	$7,443		@ 12' OC
	TOTAL CAPITAL COSTS							Total	$7,443		
	O&M COSTS										
	Inspection	Eng. Judgment	YR			$150			$150		
	Re-sealing of concrete joints	Eng. Judgment	YR			$250			$250		
	TOTAL O&M							Total	$400		
	PRESENT VALUE 30 YEARS							30-Yr PW	$12,754		See Note 6 - Includes O&M and capital costs
Slab Sealants - Coatings - New Bldg - 20,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Surface Prep	Eng. Judgment	SF			$1	$2	20,000	$20,000	$40,000	
	Urethane Membrane 1/16" - Roller Applied	MBC07100-500-2000	SF	$1		$1		20,000	$23,260	$23,260	
	TOTAL CAPITAL COSTS							Total	$43,260	$63,260	
	O&M COSTS	Similar to Synthetic Barrier				$800	$800	Total	$800	$800	Similar to synthetic barrier
	PRESENT VALUE 30 YEARS							30-Yr PW	$53,882	$73,882	See Note 6 - Includes O&M and capital costs
											Costs applicable for new construction only
	CAPITAL COSTS										
	Surface Prep	Eng. Judgment	SF			$1	$2	20,000	$20,000	$40,000	
	Epoxy	MBC03350-300-4050	SF	$2		$2		20,000	$46,520	$46,520	
	TOTAL CAPITAL COSTS							Total	$66,520	$86,520	
	O&M COSTS	Similar to Synthetic Barrier				$800	$800	Total	$800	$800	Similar to synthetic barrier
	PRESENT VALUE 30 YEARS							30-Yr PW	$77,142	$97,142	See Note 6-includes O&M and capital costs
											Costs applicable for new construction only
	CAPITAL COSTS										
	Surface Prep	Vendor Quote	SF			$1	$2	20,000	$20,000	$40,000	
	Moxie Flooring Sealant II	Vendor Quote	SF			$5		20,000	$100,000	$100,000	
	TOTAL CAPITAL COSTS							Total	$120,000	$140,000	
	O&M COSTS	Similar to Synthetic Barrier				$800	$800	Total	$800	$800	Similar to synthetic barrier
	PRESENT VALUE 30 YEARS							30-Yr PW	$130,622	$150,622	See Note 6-includes O&M and capital costs

TABLE 6-1
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - COMMERCIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2)		City/Quan-Adjusted Price		Quantity	Total Cost		Assumptions/Comments
				Low	High	Low	High		Low	High	
Floor Sealants - Admixtures New Bldg - 20,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Moxie 1800 Super Admix	Vendor Quote	CY			$21		250	$5,250		4" Thick slab
	TOTAL CAPITAL COSTS							Total	$5,250		
	O&M COSTS	Similar to Synthetic Barrier				$800		Total	$800		Similar to synthetic barrier
	PRESENT VALUE 30 YEARS							30-Yr PW	$15,872		See Note 6-includes O&M and capital costs
Traps - Dry Utilities - Cost each	**CAPITAL COSTS**										
	Crouse-Hinds EYS 1	Vendor Quote	EA			$14		30	$420		
	Installation	Eng. Judgment	EA			$50		30	$1,500		
	TOTAL CAPITAL COSTS							Total	$1,920		

NOTES
1. Costs MBC 2003 was used for costs not available in MHC 2006. Inflation was adjusted using the cost increase of a similar work item common to both 2003 & 2006 sources.
2. Low-High price variations are due to factors such as material types/sizes that cannot be determined at this time, as well as haul distance and traffic conditions.
3. MBC denotes Means Building Construction Data 2006
4. MHC denotes Means Heavy Construction Data 2003 (adjusted for inflation - See Note 1)
5. MER denotes Means Environmental Remediation Cost Data 2005
6. Present Value Calculation uses 7% net discount rate
7. Air sampling costs are for alternative comparison purposes only. A monitoring plan will be submitted to EPA after approval of the supplemental FS.

LEGEND
LS - Lump Sum EA - Each YR - Year CY - Cubic Yard LCY - Loose Cubic Yard ECY - Embankment Cubic Yard
BCY - Bank Cubic Yards SY - Square Yard LF - Lineal Foot SF - Square Foot T - Tons

TABLE 6-2
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - RESIDENTIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2)		City/Quan-Adjusted Price		Quantity	Total Cost		Assumptions/Comments
				Low	High	Low	High		Low	High	
Monitoring	**CAPITAL COSTS**					$0	$0		$0	$0	No capital costs associated with monitoring
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$100	$500		$100	$500	Low: one event every 5yrs - High: one event every yr
	Reporting	Eng. Judgment	YR			$200	$1,000		$200	$1,000	
	TOTAL O&M					$300	$1,500	Total	$300	$1,500	
	PRESENT VALUE 30 YEARS							30-Yr PW	$3,683	$18,417	See Note 6 - Includes O&M costs
Sub-Slab Passive Ventilation - 2,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Plans, Design, Permits, CM	Eng. Judgment	LS			$4,000		1	$4,000	$4,000	Engineering, planning, permitting
	Gravel/Sand Layer - Transport	MBC02315-490-1245/1255/1400	LCY	$6	$20	$7	$23	60	$419	$1,396	See Note 3, assumes 8-inch layer
	Gravel/Sand Layer - Install w/o Compaction	MBC02315-640-0050	LCY	$20	$32	$23	$37	60	$1,396	$2,233	
	Gravel/Sand Layer - Compact	MBC02315-0320-0700	ECY	$2		$2		50	$116	$116	8" thick
	Piping	MHC02620-250-2100	LF	$10		$12		400	$4,652	$4,652	Approximately 20' OC
	Geotextile Filter Fabric	MHC02620-400-0100	SY	$2		$2		250	$582	$582	
	Roof Ventilator	MBC15850-800-1300	EA	$105		$122		2	$244	$244	3" Vents
	Ductwork	MBC15810-500-1500	LF	$4		$4		50	$204	$204	Single story
	Mobe/Demobe	Eng. Judgment	LS			$2,000		1	$2,000	$2,000	
	TOTAL CAPITAL COSTS							Total	$13,612	$15,426	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$100	$500		$100	$500	Low: one event every 5yrs - High: one event every yr
	Reporting	Eng. Judgment	YR			$200	$1,000		$200	$1,000	
	TOTAL O&M					$300	$1,500	Total	$300	$1,500	
	PRESENT VALUE 30 YEARS							30-Yr PW	$17,595	$35,343	See Note 6 - Includes O&M and capital costs

TABLE 6-2
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - RESIDENTIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2)		City/Quan-Adjusted Price		Quantity	Total Cost		Assumptions/Comments
				Low	High	Low	High		Low	High	
Sub-Slab Pressurization - 2,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Same as above & add blower	See Above						See above	$13,612	$15,426	See total for passive venting
	Blower/Filter/Silencer/Gauges	Vendor Quote	EA			$1,000	$2,000	1	$1,000	$2,000	
	Slab 6" Reinf	MER18-02-0321	SF	$5		$6		64	$372	$372	Increase unit price 3x for small quantity
	Security Fence	MER33-13-2306	LS	$250		$291		1	$291	$291	
	Electrical & Controls	Eng. Judgment	LS			$1,500		1	$1,500	$1,500	
	Mobe/Demobe	Eng. Judgment	LS			$1,000		1	$1,000	$1,000	
	TOTAL CAPITAL COSTS							Total	$17,775	$20,589	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$100	$500		$100	$500	One event every 2 years
	Reporting	Eng. Judgment	YR			$200	$1,000		$200	$1,000	One annual report to EPA
	Electrical	Eng. Judgment	YR			$250	$250		$250	$250	Electrical Costs
	Maintenance	Eng. Judgment	YR			$200	$200		$200	$200	Annual maintenance of the system
	Blower Replacement (averaged)	Eng. Judgment	YR			$33	$33		$33	$33	Replace blower @ yrs 10 and 20 $5,00 per replacement (cost is averaged for 30 years)
	TOTAL O&M					$783	$1,983	Total	$783	$1,983	
	PRESENT VALUE 30 YEARS							30-Yr PW	$28,176	$46,923	See Note 6 - Includes O&M and capital costs
Sub-Slab Depressurization - 2,000 SF Footprint	Future Building										Costs applicable for new construction only
	CAPITAL COSTS	See Above							$17,775	$20,589	
	TOTAL CAPITAL COSTS							Total	$17,775	$20,589	
	O&M COSTS	See sub-slab pressurization	YR			$783	$1,983	Total	$783	$1,983	Same as sub-slab pressurization
	PRESENT VALUE 30 YEARS							Total	$28,176	$46,923	See Note 6 - Includes O&M and capital costs
	Existing Building										Costs applicable for existing buildings
	CAPITAL COSTS										
	Single unit/blower	Eng. Judgment	LS			$3,000	$7,000	1	$3,000	$7,000	
	TOTAL CAPITAL COSTS							Total	$3,000	$7,000	
	O&M COSTS	Similar to future building	YR			$783	$1,983	Total	$783	$1,983	
	PRESENT VALUE 30 YEARS							30-Yr PW	$13,401	$33,334	See Note 6 - Includes O&M and capital costs

TABLE 6-2
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - RESIDENTIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2)		City/Quan-Adjusted Price		Quantity	Total Cost		Assumptions/Comments
				Low	High	Low	High		Low	High	
Sub-Membrane Depressurization - 20,000 SF Footprint	Future Building (crawlspace)										Costs applicable for new construction only
	CAPITAL COSTS										
	Plans, Design, Permits, CM	Eng. Judgment	LS			$4,000		1	$4,000	$4,000	Engineering, planning permitting
	Membrane materials & Installation	MBC07260-100-1200	SF	$0.18		$0.20		2,000	$408	$408	
	Blower/Filter/Silencer/Gauges	Vendor Quote	EA			$1,000	$2,000	1	$1,000	$2,000	
	Security Fence	MER33-13-2306	LS	$250		$291		1	$291	$291	
	Electrical & Controls	Eng. Judgment	LS			$1,500		1	$1,500	$1,500	
	Piping	MHC02620-250-2100	LF	$10		$12		400	$4,652	$4,652	Approximately 20' OC
	Ductwork	MBC15810-500-1500	LF	$4		$4		50	$204	$204	Single story
	Mobe/Demobe	Eng. Judgment	LS			$2,000		1	$2,000	$2,000	
	TOTAL CAPITAL COSTS							Total	$14,054	$15,054	
	O&M COSTS	Similar to sub-slab depressurization				$783	$1,983		$783	$1,983	
	PRESENT VALUE 30 YEARS							30-Yr PW	$37,554	$74,554	See Note 6 - Includes O&M and capital costs
	Existing Construction (crawlspace)										Costs applicable for existing buildings
	CAPITAL COSTS										
	Single unit/blower	Eng. Judgment	LS			$3,000	$7,000	1	$3,000	$7,000	
	Plans, Design, Permits, CM	Eng. Judgment	LS			$4,000		1	$4,000	$4,000	Engineering, planning permitting
	Membrane materials & Installation	MBC07260-100-1200	SF	$0.18		$0.20		2,000	$408	$408	
	Security Fence	MER33-13-2306	LS	$250		$291		1	$291	$291	
	Electrical & Controls	Eng. Judgment	LS			$1,500		1	$1,500	$1,500	
	Piping	MHC02620-250-2100	LF	$10		$12		400	$4,652	$4,652	Approximately 20' OC
	Ductwork	MBC15810-500-1500	LF	$4		$4		50	$204	$204	Single story
	Mobe/Demobe	Eng. Judgment	LS			$2,000		1	$2,000	$2,000	0
	TOTAL CAPITAL COSTS							Total	$16,054	$20,054	
	O&M COSTS	Similar to sub-slab depressurization				$783	$1,983	Total	$783	$1,983	Replace blower @ yrs 10 and 20 $1,000 per replacement
	PRESENT VALUE 30 YEARS							30-Yr PW	$39,554	$79,554	See Note 6 - Includes O&M and capital costs
Exhaust of indoor air											Costs applicable for new or existing buildings
	CAPITAL COSTS										
	Bathroom/Kitchen Exhaust - 25 cfm	MBC15830-100-6660	EA	$83		$97		1	$97	$97	Cost varies based on size of fan
	Roof Jack	MBC15830-100-6960	EA	$61		$71		1	$71	$71	
	Duct	MBC15810-500-1500	LF	$4		$4		12	$49	$49	
	Installation	Eng. Judgment	LS			$500	$1,000	1	$500	$1,000	
	Wiring	Eng. Judgment	LS			$100	$300	1	$100	$300	
	TOTAL CAPITAL COSTS							Total	$816	$1,516	
	O&M COSTS										
	Electrical	Eng. Judgment	YR			$250	$250		$250	$250	
	Maintenance	Eng. Judgment	YR			$33	$33		$33	$33	
	TOTAL O&M					$283	$283	Total	$283	$283	
	PRESENT VALUE 30 YEARS							30-Yr PW	$8,750	$8,750	See Note 6 - Includes O&M and capital costs

TABLE 6-2
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - RESIDENTIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2)		City/Quan-Adjusted Price		Quantity	Total Cost		Assumptions/Comments
				Low	High	Low	High		Low	High	
Air Purification											Costs applicable for new or existing buildings
	CAPITAL COSTS										
	Air Purification Unit (blower/carbon vessel)	Vendor Quote	EA			$3,200		1	$3,200		
	1st Year O&M	Eng. Judgment	EA			$2,000		1	$2,000		
	TOTAL CAPITAL COSTS							Total	$5,200		
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$500			$500		Air sampling
	Reporting	Eng. Judgment	YR			$250			$250		
	Maintenance	Eng. Judgment	YR			$500			$500		Replace carbon every 3 years ($300/year). Replace unit @ years 10 & 20 ($3,200/replacement)
	TOTAL O&M	Eng. Judgment	YR			$1,250		Total	$1,250		
	PRESENT VALUE 30 YEARS							30-Yr PW	$21,797		See Note 6 - Includes O&M and capital costs
Modified-Soil Vapor Barriers - 2,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	12" Soil-Bentonite Liner - 6" Lifts	MER33-08-0505	SF	$1		$3		2,000	$6,513		Increase unit price 2x for small quantity
	Mobe/Demobe	Eng. Judgment	LS			$4,000		1	$4,000		
	TOTAL CAPITAL COSTS							Total	$10,513		
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$100			$100		Air sampling
	Reporting	Eng. Judgment	YR			$200			$200		
	TOTAL O&M					$300		Total	$300		
	PRESENT VALUE 30 YEARS							30-Yr PW	$14,496		See Note 6 - Includes O&M and capital costs
HDPE Membrane Barrier - 2,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Liner Matl & Installation	MBC07100-200-2700	SF	$2		$3		2,000	$6,000	$6,000	Assume cost sim to PVC
	Sand Blanket - 4" Lower, 4" Upper - Matl Only	MBC02315-490-1245/1255/1400	LCY	$6	$20	$7	$23	60	$419	$1,396	See Note 3
	Backfill & Compaction	MBC02315-110-1600	ECY	$3		$16		50	$776	$776	Increase unit price 5x for small quantity, difficulty
	Mobe/Demobe	Eng. Judgment	LS			$2,000		1	$2,000	$2,000	
	TOTAL CAPITAL COSTS							Total	$9,195	$10,172	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$100	$500		$100	$500	Air sampling
	Reporting	Eng. Judgment	YR			$200	$1,000		$200	$1,000	One annual report to EPA
	TOTAL O&M					$300	$1,500	Total	$300	$1,500	
	PRESENT VALUE 30 YEARS							30-Yr PW	$13,178	$30,088	See Note 6 - Includes O&M and capital costs
Synthetic Barrier - Spray - 2,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Liquid Boot ®	Vendor Quote	SF	$4	$6	$8	$12	2,000	$16,000	$24,000	Increase unit price 2x for small quantity
	TOTAL CAPITAL COSTS							Total	$16,000	$24,000	
	O&M COSTS	Similar to HDPE Barrier	YR			$300		Total	$300	$300	
	PRESENT VALUE 30 YEARS							30-Yr PW	$19,983	$27,983	See Note 6 - Includes O&M and capital costs

TABLE 6-2
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - RESIDENTIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2) Low	Price (Note 2) High	City/Quan-Adjusted Price Low	City/Quan-Adjusted Price High	Quantity	Total Cost Low	Total Cost High	Assumptions/Comments
Modified On-Grade Foundation - 2,000 SF Footprint - Additional to Std 4" slab-on-grade											Costs applicable for new construction only
	CAPITAL COSTS										
	Thickened Slab (4")	MBC03310-240-4700	CY	$165		$192		25	$4,797		8" Thick slab (4" additional concrete)
	TOTAL CAPITAL COSTS							Total	$4,797		
	O&M COSTS	Similar to HDPE Barrier	YR			$300		Total	$300		
	PRESENT VALUE 30 YEARS							30-Yr PW	$8,781		See Note 6 - Includes O&M and capital costs
											Costs applicable for new construction only
	CAPITAL COSTS										
	Slab Post-Tensioned in Place	MBC03410-650-0100	CY	$1,000	$1,200	$1,163	$1,396	50	$58,150	$69,780	8" Thick slab
	Less Standard Construction (4" Slab)	MBC03310-240-4650	CY	$197		$229		25	-$5,728	-$5,728	4" Thick slab
	TOTAL CAPITAL COSTS							Total	$52,422	$64,052	
	O&M COSTS	Similar to HDPE Barrier	YR			$300	$300	Total	$300	$300	
	PRESENT VALUE 30 YEARS							30-Yr PW	$56,406	$68,036	See Note 6 - Includes O&M and capital costs
Penetration Sealants											Costs applicable for new or existing buildings
	CAPITAL COSTS										
	Expanding Foam - Penetrations	Eng. Judgment	EA			$250	$500	2	$500	$1,000	Depending on level of effort
	TOTAL CAPITAL COSTS							Total	$500	$1,000	
	O&M COSTS										
	Inspection					$150	$150		$150	$150	Annual Inspection
	Resealing of 1 conduit	Eng. Judgment	YR			$75	$75		$75	$75	Sealing of 1 conduit every two years
	O&M COSTS					$225		Total	$225	$225	
	PRESENT VALUE 30 YEARS							30-Yr PW	$3,487	$3,987	See Note 6 - Includes O&M and capital costs
											Costs applicable for new or existing buildings
	CAPITAL COSTS										
	Pourable Polyurethane - Concrete Joints	MBC03350-325-0380	LF	$2		$2		270	$628		@ 12' OC
	TOTAL CAPITAL COSTS							Total	$628		
	O&M COSTS	Same as expanding foam	YR					Total	$225		
	PRESENT VALUE 30 YEARS							30-Yr PW	$853		See Note 6 - Includes O&M and capital costs

TABLE 6-2
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - RESIDENTIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	**Item**	**Source**	**Unit**	**Price (Note 2)**		**City/Quan-Adjusted Price**		**Quantity**	**Total Cost**		**Assumptions/Comments**
				Low	**High**	**Low**	**High**		**Low**	**High**	
Slab Sealants - Coatings - 2,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Surface Prep	Eng. Judgment	SF			$1	$2	2,000	$2,000	$4,000	
	Urethane Membrane 1/16" - Roller Applied	MBC07100-500-2000	SF	$1		$1		2,000	$2,326	$2,326	
	TOTAL CAPITAL COSTS							Total	$4,326	$6,326	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$100	$500		$100	$500	Air sampling
	Reporting	Eng. Judgment	YR			$200	$1,000		$200	$1,000	
	O&M COSTS					$300	$1,500	Total	$300	$1,500	
	PRESENT VALUE 30 YEARS							30-Yr PW	$8,309	$26,243	See Note 6 - Includes O&M and capital costs
											Costs applicable for new construction only
	CAPITAL COSTS										
	Surface Prep	Eng. Judgment	SF			$1	$2	2,000	$2,000	$4,000	
	Epoxy	MBC03350-300-4050	SF	$2		$2		2,000	$4,652	$4,652	
	TOTAL CAPITAL COSTS							Total	$6,652	$8,652	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$100	$500		$100	$500	Air sampling
	Reporting	Eng. Judgment	YR			$200	$1,000		$200	$1,000	
	O&M COSTS					$300	$1,500	Total	$300	$1,500	
	PRESENT VALUE 30 YEARS							30-Yr PW	$10,635	$28,569	See Note 6 - Includes O&M and capital costs
											Costs applicable for new construction only
	CAPITAL COSTS										
	Surface Prep	Vendor Quote	SF			$1	$2	2,000	$2,000	$4,000	
	Moxie Flooring Sealant II	Vendor Quote	SF			$8		2,000	$16,500	$16,500	
	TOTAL CAPITAL COSTS							Total	$18,500	$20,500	
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$100	$500		$100	$500	Air sampling (One sample/year)
	Reporting	Eng. Judgment	YR			$200	$1,000		$200	$1,000	
	O&M COSTS					$300	$1,500	Total	$300	$1,500	
	PRESENT VALUE 30 YEARS							30-Yr PW	$245,937	$273,692	See Note 6 - Includes O&M and capital costs

TABLE 6-2
ESTIMATED CAPITAL AND OPERATION AND MAINTENANCE COSTS - RESIDENTIAL SETTING
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Technology	Item	Source	Unit	Price (Note 2)		City/Quan-Adjusted Price		Quantity	Total Cost		Assumptions/Comments
				Low	High	Low	High		Low	High	
Floor Sealants - Admixtures - 2,000 SF Footprint											Costs applicable for new construction only
	CAPITAL COSTS										
	Moxie 1800 Super Admix	Vendor Quote	CY			$21		25	$525		4" Thick slab
	TOTAL CAPITAL COSTS							Total	$525		
	O&M COSTS										
	Sampling	Eng. Judgment	YR			$100			$100		Air sampling
	Reporting	Eng. Judgment	YR			$200			$200		
	O&M COSTS					$300		Total	$300		
	PRESENT VALUE 30 YEARS							30-Yr PW	$4,508		See Note 6 - Includes O&M and capital costs

NOTES
1. Costs MBC 2003 was used for costs not available in MHC 2006. Inflation was adjusted using the cost increase of a similar work item common to both 2003 & 2006 sources.
2. Low-High price variations are due to factors such as material types/sizes that cannot be determined at this time, as well as haul distance and traffic conditions.
3. MBC denotes Means Building Construction Data 2006
4. MHC denotes Means Heavy Construction Data 2003 (adjusted for inflation - See Note 1)
5. MER denotes Means Environmental Remediation Cost Data 2005
6. Present Value Calculation uses 7% discount rate
7. Air sampling costs are for alternative comparison purposes only. A monitoring plan will be submitted to EPA after approval of the supplemental FS.

LEGEND
LS - Lump Sum EA - Each YR - Year CY - Cubic Yard LCY - Loose Cubic Yard ECY - Embankment Cubic Yard
BCY - Bank Cubic Yards SY - Square Yard LF - Lineal Foot SF - Square Foot T - Tons

TABLE 7-1
SUMMARY OF REMEDIAL ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Alternatives	FUTURE	EXISTING	COMMERCIAL	RESIDENTIAL	Notes
1: No Action	X	X	X	X	Applicable for new and existing structures. No further action would be taken to address vapor intrusion concerns.
2: Monitoring	X	X	X	X	Applicable for new and existing structures. Can be used in areas to demonstrate that engineering controls are not needed
3: HVAC System	X	X	X		Applicable for new and existing structures. Not typically installed in residences or warehouses.
4. Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)	X		X	X	Applicable for new residential or commercial buildings. Not applicable for existing structures. Not applicable for buildings with basements below groundwater table.
5A: Sub-Slab Depressurization (SSD)	X	X	X	X	Applicable for new and existing residential or commercial buildings. Applicable for existing residents, but applicability for large commercial buildings is limited. Not applicable for buildings with basements below groundwater table.
5B: Sub-Membrane Depressurization (SMD)	X	X	X	X	Applicable for new and excisting structures with crawl spaces. Accessibility to the crawlspace could limit the implementability of SMD.
6: Sub-Slab Pressurization (SSP) and Vapor Barriers	X		X	X	Applicable for new residential or commercial buildings. Not applicable for existing structures. Not applicable for buildings with basements below groundwater table.

TABLE 7-2
DETAILED ANALYSES OF REMEDIAL ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

ALTERNATIVE	NEW	EXISTING	COMMERCIAL	RESIDENTIAL	Description	1) Overall Protection of Human Health & Environment	2) Compliance with ARARs
1: No Action	X	X	X	X	With this option, no action would be taken to address vapor intrusion concerns. Inherent in the no action option is natural ventilation because all buildings experience, at a minimum, natural ventilation through open doors and windows. They may also leak through walls or other openings in the building structure.	If vapor intrusion result in indoor air concentrations exceeding long-term exposure goals, this alternative would not be protective of human health and the environment.	If vapor intrusion result in concentrations higher than long-term exposure goals, this alternative would not reduce concentrations to below these goals.
2: Monitoring	X	X	X	X	Monitoring could be one or a combination of the following i) groundwater monitoring to evaluate whether the potential for vapor intrusion is increasing or decreasing and to confirm that the Study Area does not change, ii) Air samples to provide empirical information on the concentrations of VOCs in the enclosed space, and/or iii) soil gas samples that are typically compared to established screening levels. Similar to the no action, inherent in the monitoring alternative option is natural ventilation.	If concentrations are below long-term exposure goals, long-term monitoring can ensure the protection of human health. Monitoring could apply to areas or specific buildings over the plume where vapor intrusion has not been demonstrated to occur at levels that exceed acceptable risks. However, if vapor intrusion results in indoor air concentrations exceeding long-term exposure goals, this alternative may not be protective of the human health and the environment.	If vapor intrusion results in concentrations higher than long-term exposure goals, this alternative would not reduce concentrations to below these goals. No other ARARs are applicable for this alternative.
3: HVAC System	X	X	X		HVAC systems provide mechanical ventilation that convey outdoor air into the building enclosure. The net effect is an air exchange rate, which is defined as the rate at which the volume of indoor air is exchanged/ replaced with outdoor air. Air sample results demonstrate that allcommercial buildings with an air exchange rate of at least 1/hr generally showed TCE concentrations significantly lower than the long-term commercial exposure goal for both air-tight buildings and leaky buildings. As part of this alternative, all identified direct and leaking conduits that serve as a pathway for vapors from the subsurface to migrate into the building enclosure would be sealed prior to implementation of the system.	This alternative is protective of human health and the environment because concentrations inside the building are removed fromreduced the building to protective levels. If the ventilation system is operated at a high enough level it induces positive pressure in the building enclosure and thereby eliminates or significantly reduces the migration of VOCs into the building; otherwise it acts to dilute the concentration of VOCs that have entered the building.	This alternative complies with both long-term exposure goals and action-specific ARARs.

TABLE 7-2
DETAILED ANALYSES OF REMEDIAL ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

ALTERNATIVE	3) Long-Term Effectiveness and Permanence	4) Short-Term Effectiveness	5) Reduction of Toxicity, Mobility, or Volume through Treatment
1: No Action	This alternative does not have removal action. It can be effective, in areas or buildings where vapor intrusion is not found to cause concentrations higher than long-term exposure goals or outdoor air. Otherwise, this alternative is not effective.	Because no action is taken, this criterion does not apply.	This alternative would not reduce the toxicity, mobility, or volume.
2: Monitoring	Long-term monitoring is used to evaluate changes in the potential for vapor intrusion. For example, trends in groundwater concentrations in an area can be used to evaluate if the potential for vapor intrusion is increasing or decreasing. Indoor air samples can be used to provide empirical data on concentrations of VOCs, and to confirm that concentrations remain below long-term exposure goals. Monitoring only (i.e., without engineering controls) is not effective for buildings where indoor air concentrations result in unacceptable health risks. Groundwater sampling at the Site has been performed since the early 1980s, demonstrating the permanence of this alternative. Other types of monitoring can be collected for the long-term as long as access is provided.	Similar to long-term effectiveness.	Monitoring is not an active remedy; therefore this alternative does not reduce the toxicity, mobility, or volume of VOCs.
3: HVAC System	Sampling at the Site has demonstrated that buildings with an AE greater than 1/hr generally show concentrations below long-term exposure goals, hence demonstrating the effectiveness of ventilation. Permanence can be demonstrated through verification of operations and maintenance of ventilation systems.	This alternative is protective of worker's health during construction. Standard HVAC construction procedures would be implemented. There are no additional risks to the environment during the implementation of this alternative.	If the ventilation system is operated at a high enough level, it would induce positive pressure in the building enclosure and thereby eliminate or significantly reduce the migration of VOCs into the building; otherwise it would act to remove VOCs that have entered the building by displacement through ventilation, thereby reducing the volume of VOCs in the building. It does not change the toxicity of VOCs.

TABLE 7-2
DETAILED ANALYSES OF REMEDIAL ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

ALTERNATIVE	6) Implementability	7) Cost	Evaluation
1: No Action	This alternative can be implemented in new and existing commercial or residential developments.	The costs for the no action alternative are essentially zero. There may be relatively low costs associated with demonstrating that vapor intrusion is not occurring.	Whereas engineering controls are not necessary in some buildings or areas in the Vapor Intrusion Study Areas, the no action is not retained in the FS because at a minimum some level of monitoring and institutional controls is necessary to ensure that the potential for vapor intrusion remains insignificant.
2: Monitoring	Implementable in existing and in new commercial or residential buildings. It uses proven procedures and standard practices. Groundwater monitoring can be achieved with the existing network and no additional access requirements. Access will have to be obtained from building occupants to allow collection o air or soil-gas samples. No permits are expected for the groundwater sampling network. Collection of soil gas samples may require encroachment permits from the City of Mountain View if the samples are to be collected in the City's right of way.	There are not significant cost differentials between existing and future buildings. There are no capital costs associated with this alternative. Commercial: Annual O&M $800 to $4K. 30-year present worth $10K to $50K. Residential: Annual O&M $300 to $1.5K. 30-year present worth $4K to $19K.	This alternative is retained because it is effective and a preferable option in areas or buildings where vapor intrusion is not found to cause indoor air VOC concentrations higher than long-term exposure goals. In buildings where vapor intrusion is found to cause concentrations higher than long-term exposure goals, this alternative is not effective. Furthermore, this alternative may not be applicable for homes or buildings with subsurface structures, such as basements or earthen cellars.
3: HVAC System	This alternative is implementable for new and existing commercial or residential constructions; however, HVAC systems are not~~typically~~ generally installed in residences. HVAC systems also are not typically installed in warehouses, which rely on natural ventilation through roll up doors, on passive ventilation through wind-driven turbines in the ceiling, or on exhaust fans. Standard building permits may be needed. Most commercial buildings have HVAC systems, and modifications, if necessary are typically minor. Services and materials for this alternative are readily available. Implementability of this remedy~~is~~ may be complicated by the fact that the HVAC systems would be operated and maintained by the building owners/occupants rather than responsible parties. The responsible parties, however, would retain the responsibility to monitor the operation of HVAC systems and their effectiveness in meeting long-term exposure goals in indoor air.	Retrofitting an existing system (commercial): Capital $3.5K to $5.5K, annual O&M $4.3K to $8.5K. 30-year present worth $21K to $79K. New HVAC system (commercial): Capital $140K, annual O&M $1.3K to $5.5K. 30-year present worth $157K to $213K. Costs are not estimated for a residential setting where this alternative is not considered to be applicable	This alterative is retained as a stand-alone alternative because it can be implemented and would be effective in meeting long-term exposure goals. It is applicable to existing and new commercial buildings.

TABLE 7-2
DETAILED ANALYSES OF REMEDIAL ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

ALTERNATIVE	NEW	EXISTING	COMMERCIAL	RESIDENTIAL	Description	1) Overall Protection of Human Health & Environment	2) Compliance with ARARs
4: Sub-Slab-Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)	X		X	X	This alternative would consist of a passive sub-slab ventilation system and a vapor barrier. A passive sub-slab ventilation system would include a gravel and/or sand layer with perforated pipe manifolded to vent risers. The vent risers typically end with a wind-driven turbine that induce flow from the subsurface to the outside.	This alternative is protective of human health and the environment in that the passive system and the vapor barrier eliminate the vapor intrusion pathway.	This alternative is well demonstrated in the field and complies with both long-term exposure goals and action-specific ARARs.
5A: Sub-Slab Depressurization (SSD)	X	X	X	X	A SSD system typically consists of sub-slab sand/gravel layer with a piping system and blower. The system is operated to create a slight negative pressure under the building slab, inducing flow of sub-slab air into the pipe. As part of this alternative, all identified direct and leaking conduits that serve as a pathway for vapors from the subsurface to migrate into the building enclosure would be sealed prior to implementation of the system.	This alternative is protective of human health and the environment in that VOCs are removed from the subsurface. A SSD system reduces potential risks from vapor intrusion.	This alternative complies with both long-term exposure goals and action-specific ARARs. A BAAQMD permit may be required.
5B: Sub-Membrane Depressurization (SMD)	X	X	X	X	An SMD system is similar to an SSD system except that it is installed below a membrane instead of a slab, when slabs are absent, such as in buildings with crawlspaces. The SMD creates lower sub-membrane air pressure relative to the crawlspace air pressure by use of a fan powered vent to draw air from soils under the membrane. As part of this alternative, all identified direct and leaking conduits that serve as a pathway for vapors from the subsurface to migrate into the building enclosure would be sealed prior to implementation of the system.	This alternative is protective of human health and the environment in that VOCs are removed from the subsurface. An SMD system reduces potential risks from vapor intrusion.	This alternative complies with both long-term exposure goals and action-specific ARARs. A BAAQMD permit may be required.

TABLE 7-2
DETAILED ANALYSES OF REMEDIAL ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

ALTERNATIVE	3) Long-Term Effectiveness and Permanence	4) Short-Term Effectiveness	5) Reduction of Toxicity, Mobility, or Volume through Treatment
4: Sub-Slab-Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)	The effectiveness of this alternative depends on the design and installation quality as well as on long-term maintenance. This alternative is passive, and therefore it will be present as long as the structure is present. Modifications to the building should either not penetrate the vapor barrier, or allow for proper replacement and sealing of the removed vapor barrier.	This alternative is protective of worker's health during construction. Standard construction procedures would be implemented. There are no additional risks or impacts to the environment during the implementation of this alternative.	This technology eliminates the mobility of VOCs into buildings and the mass of VOCs that potentially may migrate into a building enclosure. It does not reduce the toxicity of VOCs.
5A: Sub-Slab Depressurization (SSD)	By creating a negative pressure zone under the building, the vapor migration pathway would be eliminated. Indoor air concentrations would be similar to outdoor air concentrations, and the risks would be similar to those of breathing outdoor air. It is anticipated that an SSD system would operate until the potential for vapor intrusion is reduced so that indoor air concentrations attributed to the vapor intrusion pathway are below long-term exposure goals.	This alternative is protective of worker's health during construction. Standard construction procedures would be implemented. There are no additional risks to the environment during the implementation of this alternative.	SSD reduces the mobility of VOCs into buildings and the mass of VOCs that potentially may migrate into a building enclosure. SSD does not necessarily reduce the toxicity of VOCs.
5B: Sub-Membrane Depressurization (SMD)	An SMD system would remove the chemicals potentially collected in soil gas beneath the crawlspace. The membrane covers all of the soil below the building floor, and thereby blocking the vapor intrusion pathway. This technology will not result in concentrations greater than long term goals.	This alternative is protective of worker's health during construction. Standard construction procedures would be implemented. There are no additional risks to the environment during the implementation of this alternative.	SMD reduces the mobility of VOCs into buildings and the mass of VOCs that potentially may migrate into a building enclosure. SMD does not necessarily reduce the toxicity of VOCs.

TABLE 7-2
DETAILED ANALYSES OF REMEDIAL ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

ALTERNATIVE	6) Implementability	7) Cost	Evaluation
4: Sub-Slab-Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)	This alternative can be implemented in new commercial or residential developments, but cannot be implemented in existing residential or commercial structures. Only standard building permits would be required. Services and materials for this alternative are readily available. Installation of vapor barriers requires specialized skills and licensed contractors.	Because this alternative is implementable in future buildings, costs were developed for future residential and commercial buildings only. Commercial - future: Capital $162K to $189K, annual O&M $800 to $4K. 30-year present worth $173K to $242K. Residential - future: Capital $23K to $26K, annual O&M $300 to $1.5K. 30-year present worth $27K to $46K.	This alternative is retained as a stand-alone alternative because it can be implemented and would be effective in meeting long-term exposure goals. It can be used for new commercial and residential structures. It is not applicable to existing residential and commercial structures.
5A: Sub-Slab Depressurization (SSD)	This alternative can be implemented in new commercial and new or existing residential developments. Implementability for large existing commercial structures is limited. Depending on emissions, the BAAQMD may require a permit. Otherwise, only standard building permits would be required. Services and materials for this alternative are readily available.	Commercial - future: Capital $103K to $123K, annual O&M $7K to $12K. 30-year present worth $196K to $286K. Commercial - existing: Capital $133K to $221K, annual O&M $9K to $13K. 30-year present worth $253K to $397K. Residential - future: Capital $18K to $21K, annual O&M $800 to $2K. 30-year present worth $29K to $47K. Residential - existing: Capital $3K to $7K, annual O&M $800 to $2K. 30-year present worth $14K to $34K.	This alternative is retained as a stand-alone alternative because it can be implemented and would be effective in meeting long-term exposure goals in new commercial and residential developments. It can also be used for existing residential structures, if necessary, and for warehouses. Its application to existing commercial structures or structures with basements beneath the water table is limited.
5B: Sub-Membrane Depressurization (SMD)	This alternative can be implemented in future and existing residential developments with crawlspaces. It is reliable and uses proven procedures and standard construction practices. Accessibility to the crawlspace could limit the implementability of SMD. For example, sufficient headspace should be present to allow placement of the membrane in the crawlspace, and subsequent seating to footings, wells and pipes.	Commercial - future: Capital $74K to $77K, annual O&M $7K to $12K. 30-year present worth $167K to $239K. Commercial - existing: Capital $139K to $227K, annual O&M $9K to $13K. 30-year present worth $259K to $403K. Residential - future: Capital $14K to $15K, annual O&M $800 to $2K. 30 year present worth $38K to $75K. Residential - existing: Capital $16K to $20K, annual O&M $800. 30-year present worth $40K to $44K.	This alternative is retained as a stand-alone alternative because it can be implemented and would be effective in meeting long-term exposure goals in new and existing commercial and residential developments with crawlspaces. The headspace in the crawlspace should allow access to install and seal the membrane, and to install the depressurization equipment.

ALTERNATIVE	NEW	EXISTING	COMMERCIAL	RESIDENTIAL	Description	1) Overall Protection of Human Health & Environment	2) Compliance with ARARs
6: Sub-Slab Pressurization (SSP) and Vapor Barrier	X		X	X	This alternative is similar to the one above, except that vapor barriers would be used instead of surface coatings to seal cracks The vapor barrier would eliminate the potential of pressure-induced flow through openings in the slab.	This alternative is protective of human health and the environment in that VOCs are removed from the subsurface. The vapor barrier would eliminate the pressure-induced flow into openings in the slab such as cracks and seams around conduits.	This alternative is well demonstrated in the field and complies with both long-term exposure goals and action-specific ARARs.

TABLE 7-2
DETAILED ANALYSES OF REMEDIAL ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

ALTERNATIVE	3) Long-Term Effectiveness and Permanence	4) Short-Term Effectiveness	5) Reduction of Toxicity, Mobility, or Volume through Treatment
6: Sub-Slab Pressurization (SSP) and Vapor Barrier	Indoor air concentrations would be similar to outdoor air concentrations, and the risks would be similar to those of breathing outdoor air. It is anticipated that an SSP system would operate until the potential for vapor intrusion is reduced so that indoor air concentrations attributed to the vapor intrusion pathway are below long-term exposure goals.	This alternative is protective of worker's health during construction. Standard construction procedures would be implemented. There are no additional risks to the environment during the implementation of this alternative.	This technology eliminates the mobility of VOCs into buildings and the mass of VOCs that potentially may migrate into a building enclosure. It does not reduce the toxicity of VOCs.

TABLE 7-2
DETAILED ANALYSES OF REMEDIAL ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

ALTERNATIVE	6) Implementability	7) Cost	Evaluation
6: Sub-Slab Pressurization (SSP) and Vapor Barrier	This alternative can be implemented in new commercial or residential developments, but not in existing residential or commercial structures. Only standard building permits would be required. Services and materials for this alternative are readily available. Installation of synthetic vapor barriers requires specialized skills and licensed contractors.	Because this alternative is implementable in future buildings, costs were developed for future residential and commercial buildings only. Commercial: Capital $176K to $206K, annual O&Ms $7K to $12K. 30-year present worth $269K to $368K. Residential : Capital $28K to $32K, annual O&M $800 to $2K. 30-year present worth $40K to $80K.	This alternative is retained as a stand-alone alternative because it can be implemented and would be effective in meeting long-term exposure goals. It can be used for new commercial and residential structures. It is not applicable to exiting residential and commercial structures.

TABLE 7-2
DETAILED ANALYSES OF REMEDIAL ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

ALTERNATIVE	NEW	EXISTING	COMMERCIAL	RESIDENTIAL	Description	1) Overall Protection of Human Health & Environment	2) Compliance with ARARs

Notes:
1. This criterion provides a final check to assess whether the alternative is protective of human health and the environment. This evaluation describes how potential risks from vapor intrusion are eliminated, reduced or controlled by the alternative.

2. Each alternative is evaluated to assess whether it meets Federal and State ARARs. The analyses summarize which requirements are applicable or relevant and appropriate to the alternative, and how the alternative meets these requirements. Compliance with the three types of ARARs is assessed: chemi specific, location-specific and action-specific.

3. This criterion addresses the alternative in terms of risks remaining after response objectives are met. The following two components are addressed for each alternative:
- Magnitude of residual risks, to assess residual risks remaining after conclusion of the remedial activity.
- Adequacy and reliability of controls used to manage residuals. This factor also addresses the long-term reliability of management controls for continued protection from residuals.

4. This evaluation criterion addresses effects of the alternative during the construction and implementation phase until the objectives are met. Under this criterion, alternatives are evaluated with respect to their effects on human health and the environment during implementation of the removal or remedial action. The following factors are considered for each alternative:
- Protection of community health during the removal or remedial actions (e.g., risks that may result from implementation of the alternative)
- Protection of workers' health during the removal or remedial actions
- Time until objectives are achieved
- Environmental impacts, if any (adverse impacts on the environment as a result of the activity and reliability of mitigation measures in preventing or reducing the potential impacts)

5. In evaluating this criterion, an assessment is made as to whether the alternative reduces principal threats, including extent to which toxicity, mobility, or volume is reduced either alone or in combination. The following factors are considered for each alternative:
- The treatment processes to be used, and materials to be treated
- The amount of hazardous materials to be treated, if any
- The estimated degree of expected reduction in toxicity, mobility, or volume
- The degree to which the treatment is irreversible
- The type and quantity of treatment residuals expected to remain after treatment

6. The implementability criterion addresses the technical and administrative feasibility of implementing a removal action alternative and the availability of various services and materials required during its implementation. This criterion involves analysis of the following factors:
- Technical feasibility. This relates to feasibility of construction and operation of the alternative, the reliability of the alternative, the ease of undertaking additional removal action, if any, and the ability to monitor the effectiveness of the remedy.
- Administrative feasibility. Examples are operating permits/approvals and access.
- Availability of services and materials. This includes the availability of personnel and technology; off-site treatment, storage and disposal capacity and services; and availability of necessary services, equipment, materials and specialists.

7. Developed for a typical 20,000 square foot commercial building and 2,000 square residence, when applicable. The cost criterion evaluates alternatives based on economic considerations, which primarily consist of cost estimates derived for each alternative. The cost estimates usually include the capital cost and annual O&M costs. The costs for each alternative are estimates, and their accuracy may be within -30 percent to +50 percent of the final project cost. The estimates of capital cost for each alternative consists of direct (construction: equipment, labor, materials, services, disposal) and indirect (non-construction and overhead: engineering, financial, license or permit, startup/shakedown, contingencies) costs. Capital costs for each removal alternative can be obtained from literature sources, vendor quotes and previous studies. Annual O&M costs are the post-construction costs necessary to ensure the continued effectiveness of the removal action. Annual costs include operating labor costs, maintenance materials and labor expenses, auxiliary materials and utilities, disposal of any residuals, administrative costs and monitoring/support costs. A present worth analysis is performed to compare costs for each alternative, and a sensitivity analysis is performed on the costs as applicable.

TABLE 7-3
SUMMARY OF ALTERNATIVES COSTS
30-YEAR PRESENT WORTH ESTIMATES - COMMERCIAL SCENARIO
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Alternative	**Existing Construction**		**Future Construction**	
	Low	**High**	**Low**	**High**
2: Monitoring	$10,000	$50,000	$10,000	$50,000
3: HVAC System	$21,000	$79,000	$157,000	$213,000
4. Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)	NA	NA	$173,000	$242,000
5A: Sub-Slab Depressurization (SSD)	$253,000	$397,000	$196,000	$286,000
5B: Sub-Membrane Depressurization (SMD)	$259,000	$403,000	$167,000	$239,000
6: Sub-Slab Pressurization (SSP) and Vapor Barriers	NA	NA	$269,000	$368,000

Notes:
1. Based on a typical building size of 20,000 sq ft.
2. The present worth estimates are based on a discount rate of 7 percent.
3. Accuracy of estimates may be within -30 percent to +50 percent of the final project cost.
4. NA = not applicable
5. Alternative 3 (HVAC) may include sealing leaking conduits and the use of air purification unit(s). Costs for these additional measures are not included in the estimate, as they may not be necessary. These costs are relatively small compared to the overall cost of the Alternative.

6. Alternatives 5A and 5B (SSD and SMD) may include sealing leaking conduits. Costs for this additional measure is not included in the estimate, as it may not be necessary. These costs are relatively small compared to the overall cost of the Alternative.

TABLE 7-4
SUMMARY OF ALTERNATIVES COSTS
30-YEAR PRESENT WORTH ESTIMATES - RESIDENTIAL SCENARIO
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CA

Alternative	**Existing Construction**		**Future Construction**	
	Low	**High**	**Low**	**High**
2: Monitoring	$4,000	$19,000	$4,000	$19,000
3: HVAC System	NA	NA	NA	NA
4. Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)	NA	NA	$27,000	$46,000
5A: Sub-Slab Depressurization (SSD)	$14,000	$34,000	$29,000	$47,000
5B: Sub-Membrane Depressurization (SMD)	$40,000	$80,000	$38,000	$75,000
6: Sub-Slab Pressurization (SSP) and Vapor Barriers	NA	NA	$38,000	$58,000

Notes:
1. Based on a typical building size of 2,000 sq ft.
2. The present worth estimates are based on a discount rate of 7 percent.
3. Accuracy of estimates may be within -30 percent to +50 percent of the final project cost.
4. NA = not applicable

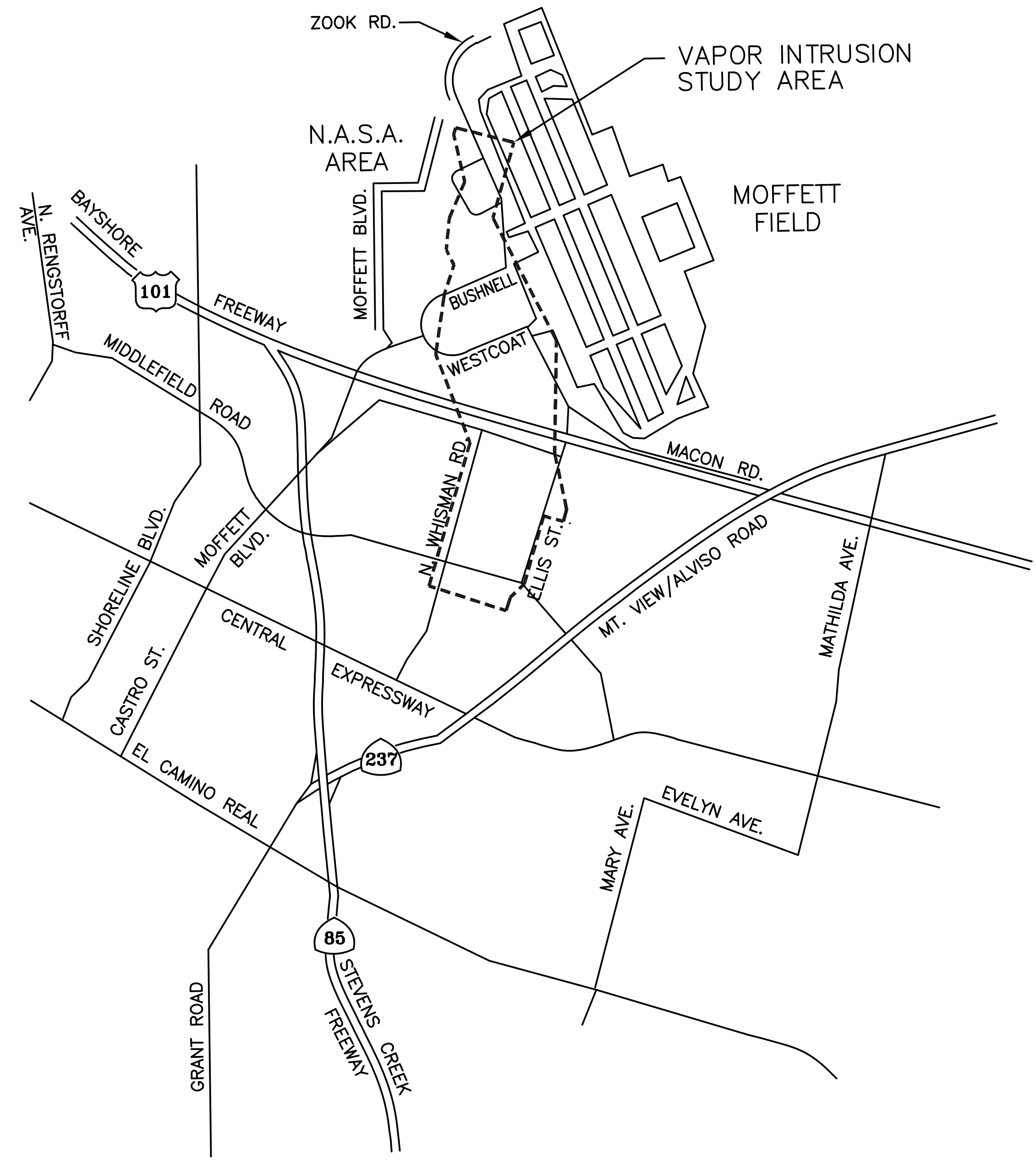
5. Alternatives 5A and 5B (SSD and SMD) may include sealing leaking conduits. Costs for this additional measure is not included in the estimate, as it may not be necessary. These costs are relatively small compared to the overall cost of the Alternative.

TABLE 9-3
SUMMARY OF RECOMMENDED ALTERNATIVES
FINAL SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION PATHWAY
MEW STUDY AREA

BUILDING SCENARIO	**RECOMMENDED ALTERNATIVE [1]**
EXISTING BUILDINGS	
Commercial (with existing HVAC system)	Alternative 3: HVAC System
Commercial (without existing HVAC system)	Alternative 5A/B: Sub-slab/membrane Depressurization
Residential	Alternative 5A/B: Sub-slab/membrane Depressurization
FUTURE BUILDINGS	
Commercial (on properties overlying low groundwater concentrations [TCE < 100 ppb [2]])	Alternative 4: Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)
Commercial (on properties overlying higher groundwater concentrations [TCE > 100 ppb])	Alternative 5A/B: Sub-slab/membrane Depressurization
Residential (on properties overlying low groundwater concentrations [TCE < 50 ppb])	Alternative 4: Sub-Slab Passive Ventilation with Vapor Barrier (with Ability to Convert to Active)
Residential (on properties overlying higher groundwater concentrations [TCE > 50 ppb])	Alternative 5A/B: Sub-slab/membrane Depressurization

Notes:
1. When an engineering control is necessary.
2. ppb = parts per billion, or micrograms per liter

FIGURES



SITE LOCATION MAP
MOUNTAIN VIEW, CALIFORNIA

PREPARED FOR

MEW COMPANIES

N

0 2,000 4000 FEET

SCALE: 1"= 4,000'

DRAWING NO. 97–023–A45

FIGURE 1–1

LOCUS TECHNOLOGIES

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
1	06–15–09	ISSUED FOR REPORT	CWC	JM	PP

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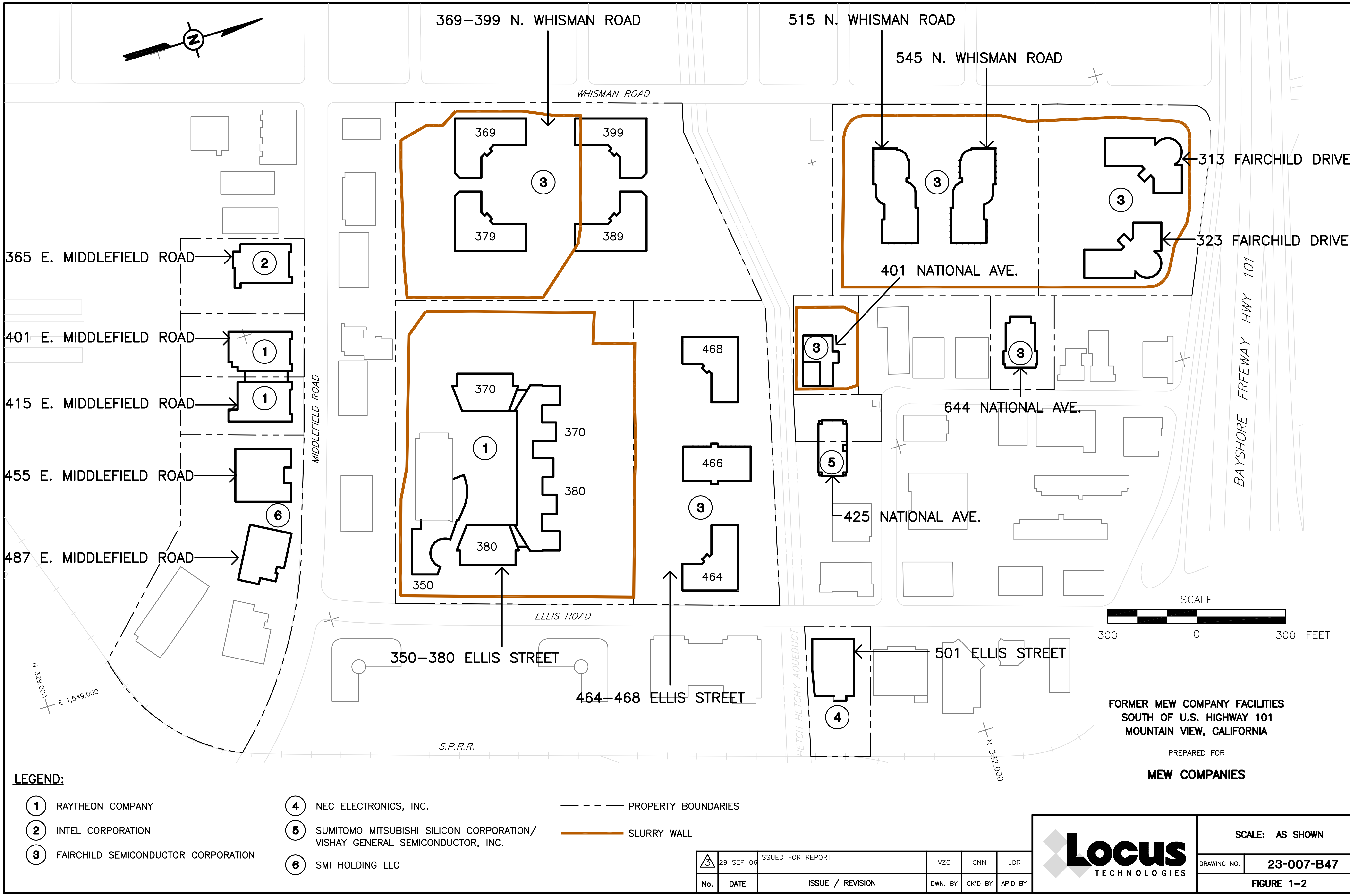

369–399 N. WHISMAN ROAD
515 N. WHISMAN ROAD
545 N. WHISMAN ROAD
WHISMAN ROAD
313 FAIRCHILD DRIVE
323 FAIRCHILD DRIVE
401 NATIONAL AVE.
644 NATIONAL AVE.
425 NATIONAL AVE.
365 E. MIDDLEFIELD ROAD
401 E. MIDDLEFIELD ROAD
415 E. MIDDLEFIELD ROAD
455 E. MIDDLEFIELD ROAD
487 E. MIDDLEFIELD ROAD
MIDDLEFIELD ROAD
369
399
379
389
370
380
350
468
466
464
ELLIS ROAD
350–380 ELLIS STREET
464–468 ELLIS STREET
501 ELLIS STREET
HETCH HETCHY AQUEDUCT
S.P.R.R.
BAYSHORE FREEWAY HWY 101
N 329,000
E 1,549,000
N 332,000
SCALE
300 0 300 FEET
FORMER MEW COMPANY FACILITIES
SOUTH OF U.S. HIGHWAY 101
MOUNTAIN VIEW, CALIFORNIA
PREPARED FOR
MEW COMPANIES
LEGEND:
1 RAYTHEON COMPANY
2 INTEL CORPORATION
3 FAIRCHILD SEMICONDUCTOR CORPORATION
4 NEC ELECTRONICS, INC.
5 SUMITOMO MITSUBISHI SILICON CORPORATION/ VISHAY GENERAL SEMICONDUCTOR, INC.
6 SMI HOLDING LLC
PROPERTY BOUNDARIES
SLURRY WALL
3 29 SEP 06 ISSUED FOR REPORT VZC CNN JDR
No. DATE ISSUE / REVISION DWN. BY CK'D BY AP'D BY
Locus TECHNOLOGIES
SCALE: AS SHOWN
DRAWING NO. 23-007-B47
FIGURE 1–2
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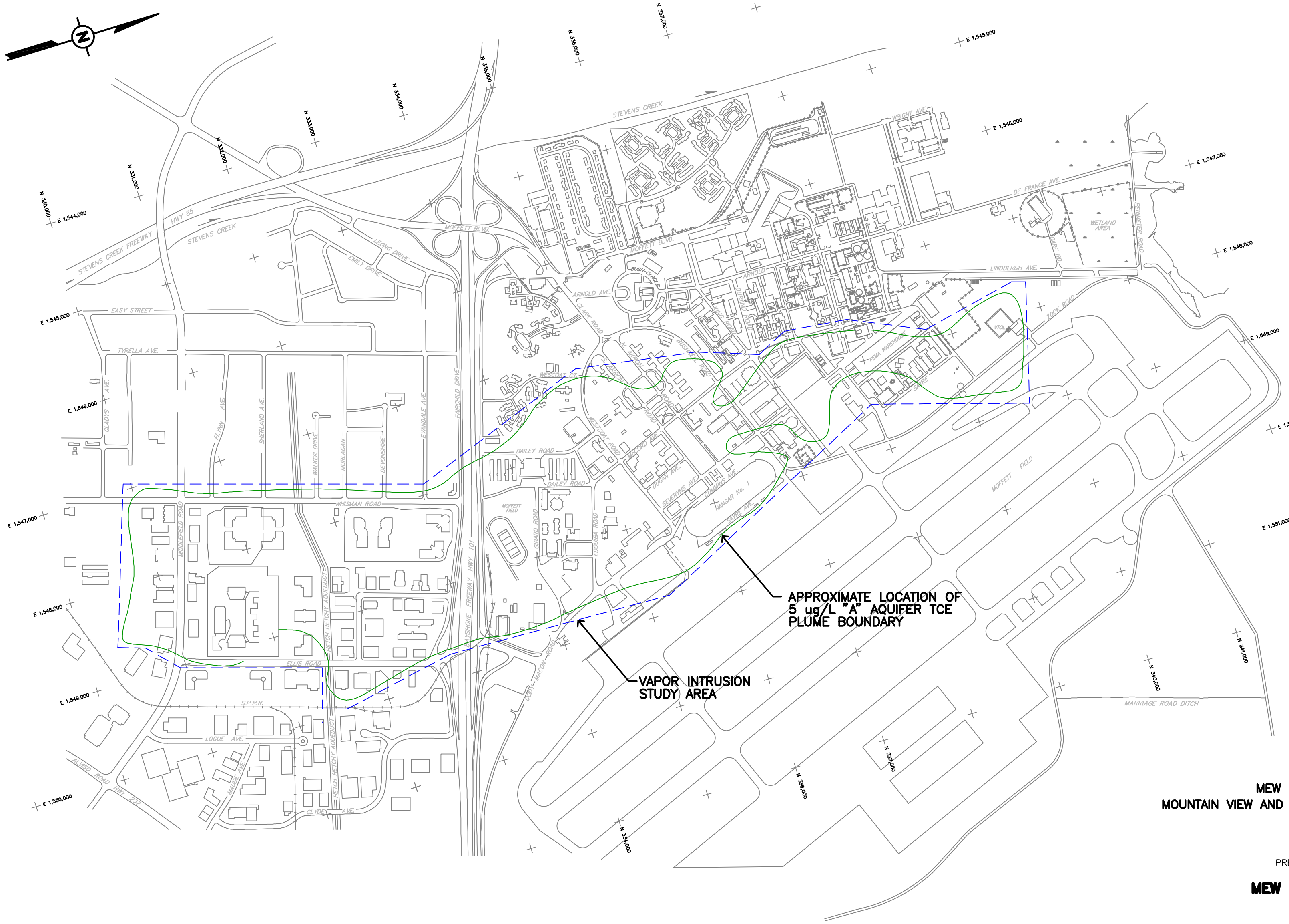

MEW STUDY AREA
MOUNTAIN VIEW AND MOFFETT FIELD, CALIFORNIA

PREPARED FOR

MEW COMPANIES

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
2	29 SEP 06	ISSUED FOR REPORT	VZC	CNN	JDR

Locus TECHNOLOGIES

SCALE: 500 0 500 1000 FEET

DRAWING NO. 23-007-E131

FIGURE 2-1

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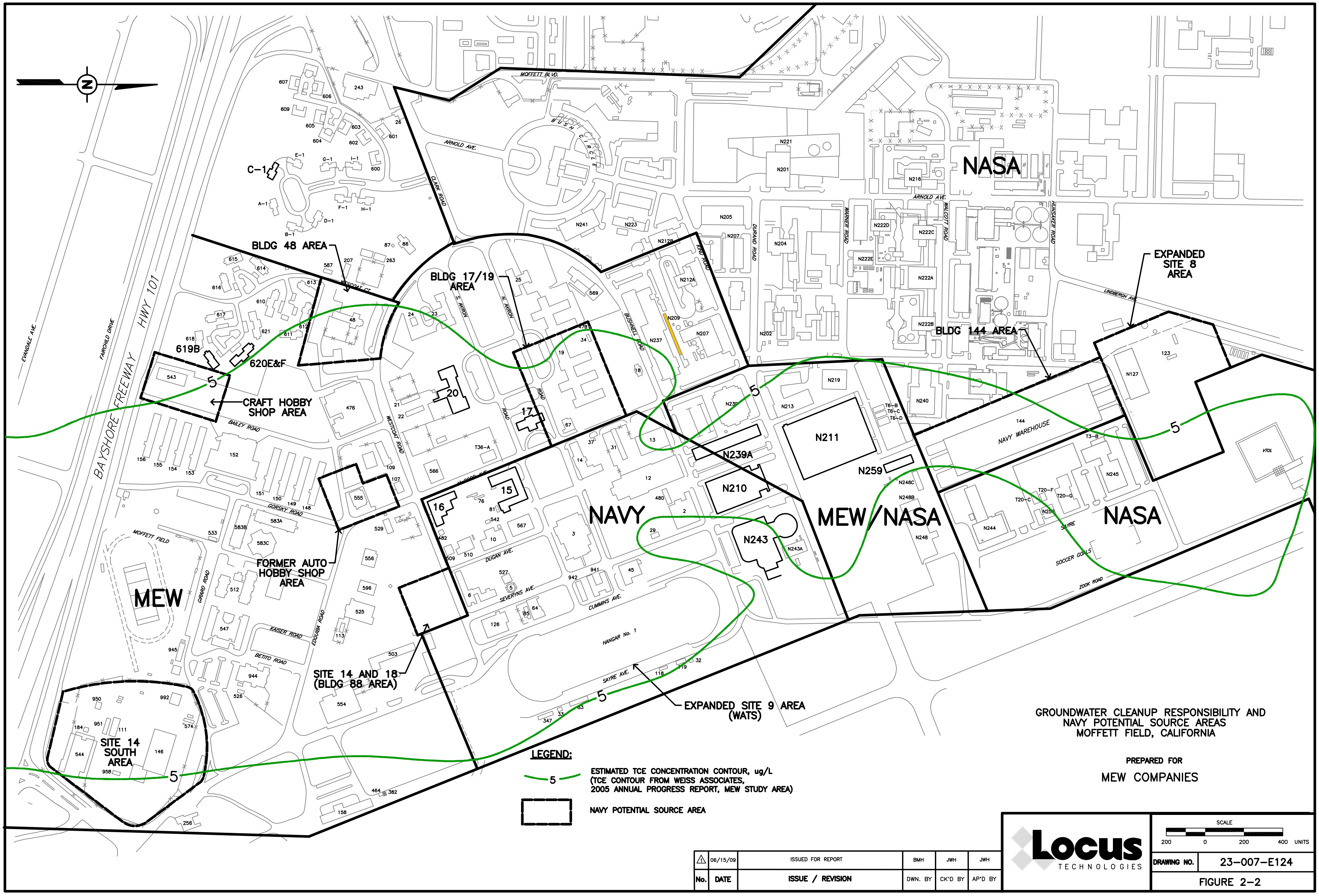

NASA
NAVY
MEW/NASA
NASA
MEW
BLDG 48 AREA
BLDG 17/19 AREA
BLDG 144 AREA
EXPANDED SITE 8 AREA
CRAFT HOBBY SHOP AREA
FORMER AUTO HOBBY SHOP AREA
SITE 14 AND 18 (BLDG 88 AREA)
EXPANDED SITE 9 AREA (WATS)
SITE 14 SOUTH AREA
619B
620E&F
C-1
N211
N210
N239A
N259
N243
MOFFETT BLVD.
ARNOLD AVE.
CLARK ROAD
BUSH CIRCLE
WESTCOAT ROAD
BAILEY ROAD
GOMSKY ROAD
DUGAN AVE.
SEVERYNS AVE.
CUMMINS AVE.
SAYRE AVE.
HANGAR No. 1
NAVY WAREHOUSE
SOCCER GOALS
ZOOK ROAD
LINDBERGH AVE.
BAYSHORE FREEWAY HWY 101
FAIRCHILD DRIVE
EVANDALE AVE.
MOFFETT FIELD
KAISER ROAD
BETITO ROAD
LEGEND:
ESTIMATED TCE CONCENTRATION CONTOUR, ug/L (TCE CONTOUR FROM WEISS ASSOCIATES, 2005 ANNUAL PROGRESS REPORT, MEW STUDY AREA)
NAVY POTENTIAL SOURCE AREA
GROUNDWATER CLEANUP RESPONSIBILITY AND NAVY POTENTIAL SOURCE AREAS MOFFETT FIELD, CALIFORNIA
PREPARED FOR
MEW COMPANIES
Locus TECHNOLOGIES
SCALE
200 0 200 400 UNITS
DRAWING NO. 23-007-E124
FIGURE 2-2
1 06/15/09 ISSUED FOR REPORT BMH JWH JWH
No. DATE ISSUE / REVISION DWN. BY CK'D BY AP'D BY
K:\23-007\E124 Fig 2-2.dwg 15 June 2009

COMMERCIAL BUILDINGS SAMPLED
SOUTH OF U.S. HIGHWAY 101
MOUNTAIN VIEW, CALIFORNIA

PREPARED FOR

MEW COMPANIES

Locus TECHNOLOGIES

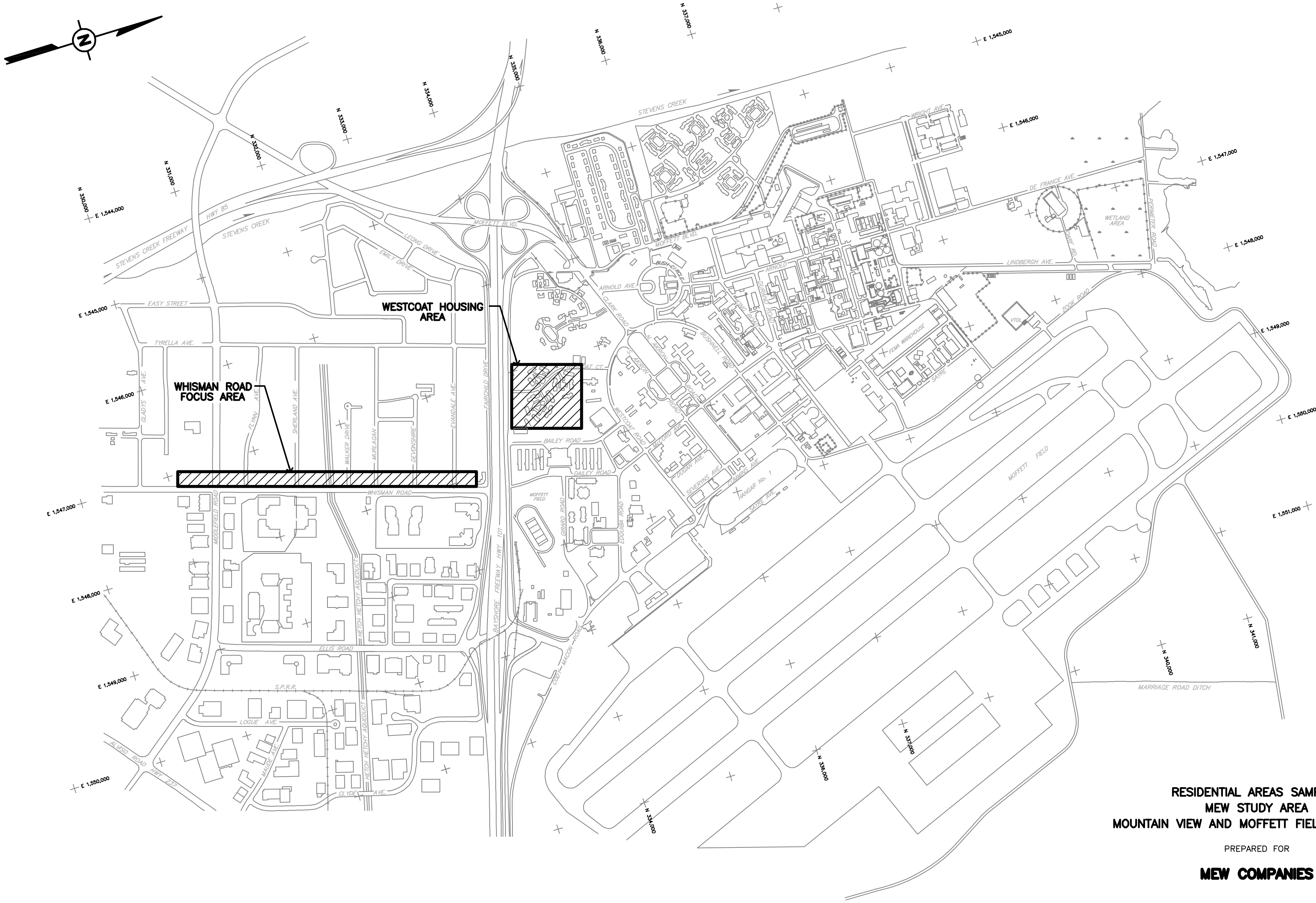
No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
	29 SEP 06	ISSUED FOR REPORT	VZC	CNN	JDR

SCALE 200 0 200 400 FEET

DRAWING NO. 23-007-E89

FIGURE 2-3

K:\23-007\E89.DWG 12 JUL 06



RESIDENTIAL AREAS SAMPLED
MEW STUDY AREA
MOUNTAIN VIEW AND MOFFETT FIELD, CALIFORNIA

PREPARED FOR

MEW COMPANIES

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
2	19 DEC 07	ISSUED FOR REPORT	RP/VZC	CNN	JDR

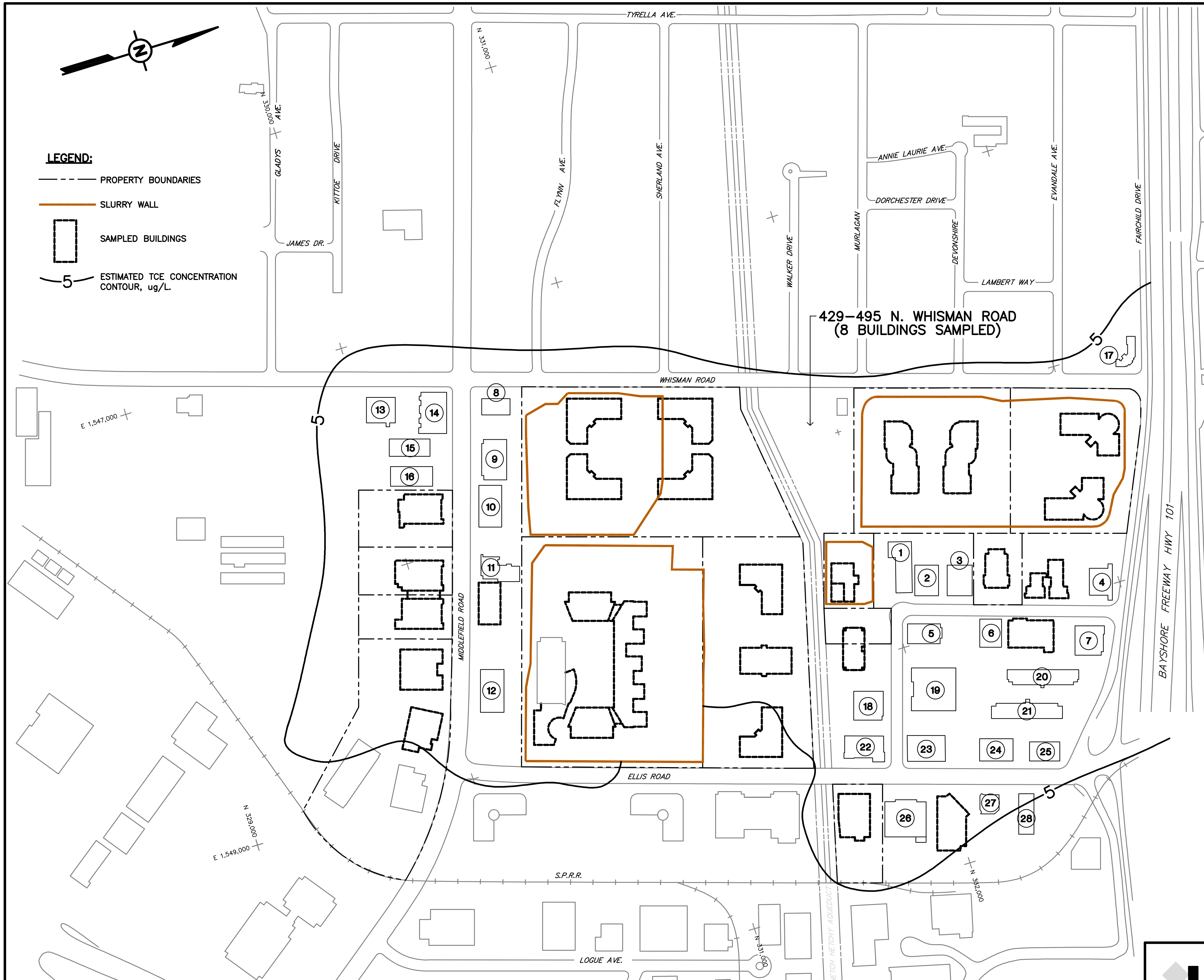
Locus TECHNOLOGIES

SCALE
500 0 500 1000 FEET

DRAWING NO. 23-007-E125

FIGURE 2-4

K:\23-007\E125 FIG 2-4.DWG 15 JUN 09



NOTES:

BUILDINGS TO BE EVALUATED:

1. 612–620 NATIONAL AVENUE
2. 630 NATIONAL AVENUE
3. 640 NATIONAL AVENUE
4. 331/333 FAIRCHILD DRIVE
5. 615 NATIONAL AVENUE
6. 625 NATIONAL AVENUE
7. 411/415 FAIRCHILD DRIVE
8. 301 N. WHISMAN ROAD
9. 340–348 E. MIDDLEFIELD ROAD
10. 440 E. MIDDLEFIELD ROAD
11. 448 E. MIDDLEFIELD ROAD
12. 490 E. MIDDLEFIELD ROAD
13. 265/275 N. WHISMAN ROAD
14. 325 E. MIDDLEFIELD ROAD
15. 335 E. MIDDLEFIELD ROAD
16. 345 E. MIDDLEFIELD ROAD
17. 299 FAIRCHILD DRIVE
18. 465 NATIONAL AVENUE
19. 450 NATIONAL AVENUE
20. 465 FAIRCHILD DRIVE, BLDG. B
21. 465 FAIRCHILD DRIVE, BLDG. A
22. 486 ELLIS STREET
23. 500 ELLIS STREET
24. 550 ELLIS STREET
25. 491 FAIRCHILD DRIVE
26. 515 ELLIS STREET
27. 605 ELLIS STREET
28. 625 ELLIS STREET

COMMERCIAL BUILDINGS TO BE EVALUATED SOUTH OF U.S. HIGHWAY 101 MOUNTAIN VIEW, CALIFORNIA

PREPARED FOR

MEW COMPANIES

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
1	29 SEP 06	ISSUED FOR REPORT	VZC	CNN	JDR

Locus TECHNOLOGIES

SCALE: 200 0 200 400 FEET

DRAWING NO. 23-007-E126

FIGURE 2–5

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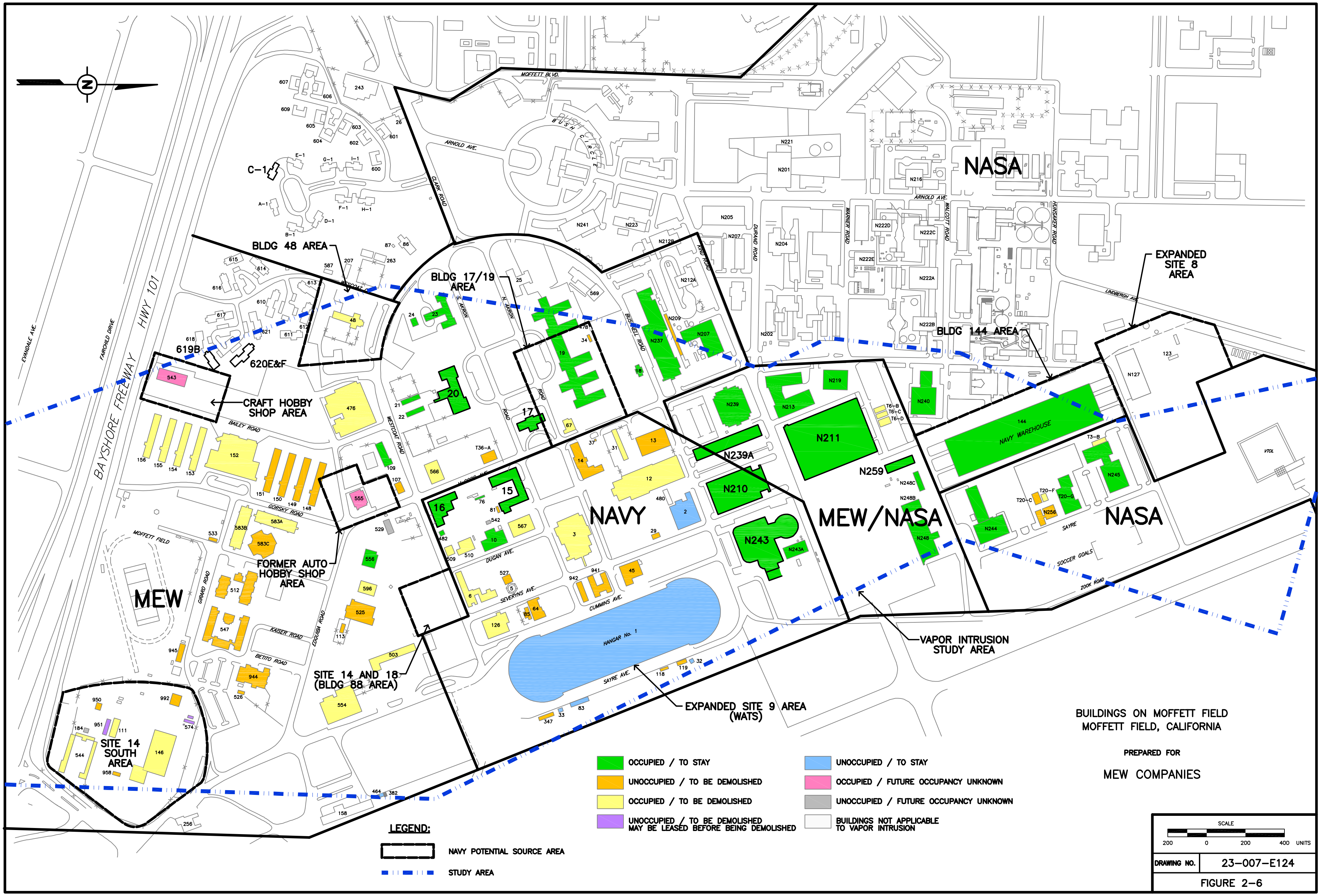
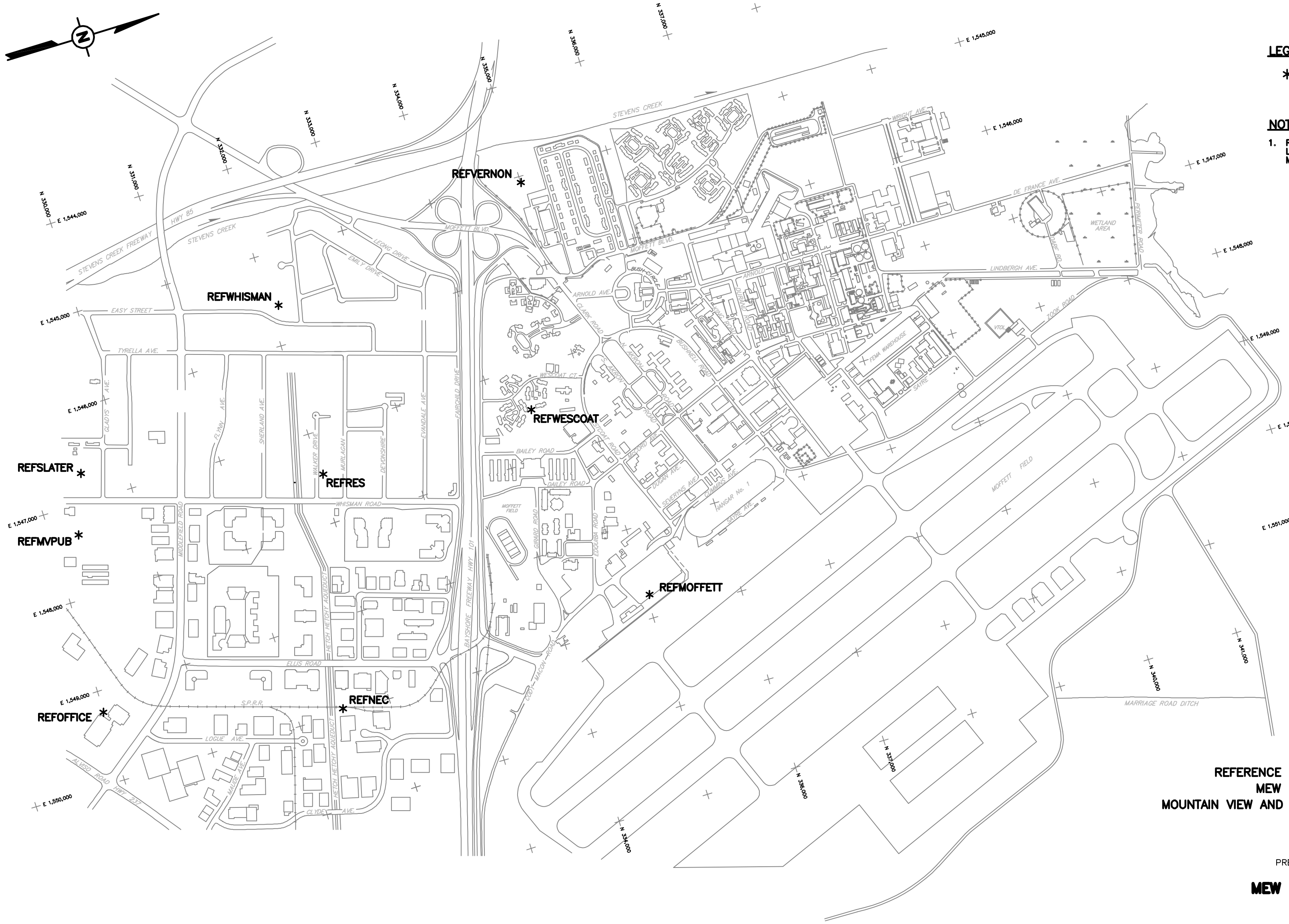


K:\23-007\E124.dwg 22 April 2009



LEGEND:

* REFRES REFERENCE SAMPLE LOCATION

NOTES:

1. REFERENCE SAMPLE LOCATIONS WERE LOCATED 0.25–1 MILES FROM THE MEW SITE.

REFERENCE SAMPLE LOCATIONS
MEW STUDY AREA
MOUNTAIN VIEW AND MOFFETT FIELD, CALIFORNIA

PREPARED FOR

MEW COMPANIES

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
2	29 SEP 06	ISSUED FOR REPORT	VZC	CNN	JDR

Locus TECHNOLOGIES

SCALE: 500 0 500 1000 FEET

DRAWING NO. 23-007-E127

FIGURE 5-1

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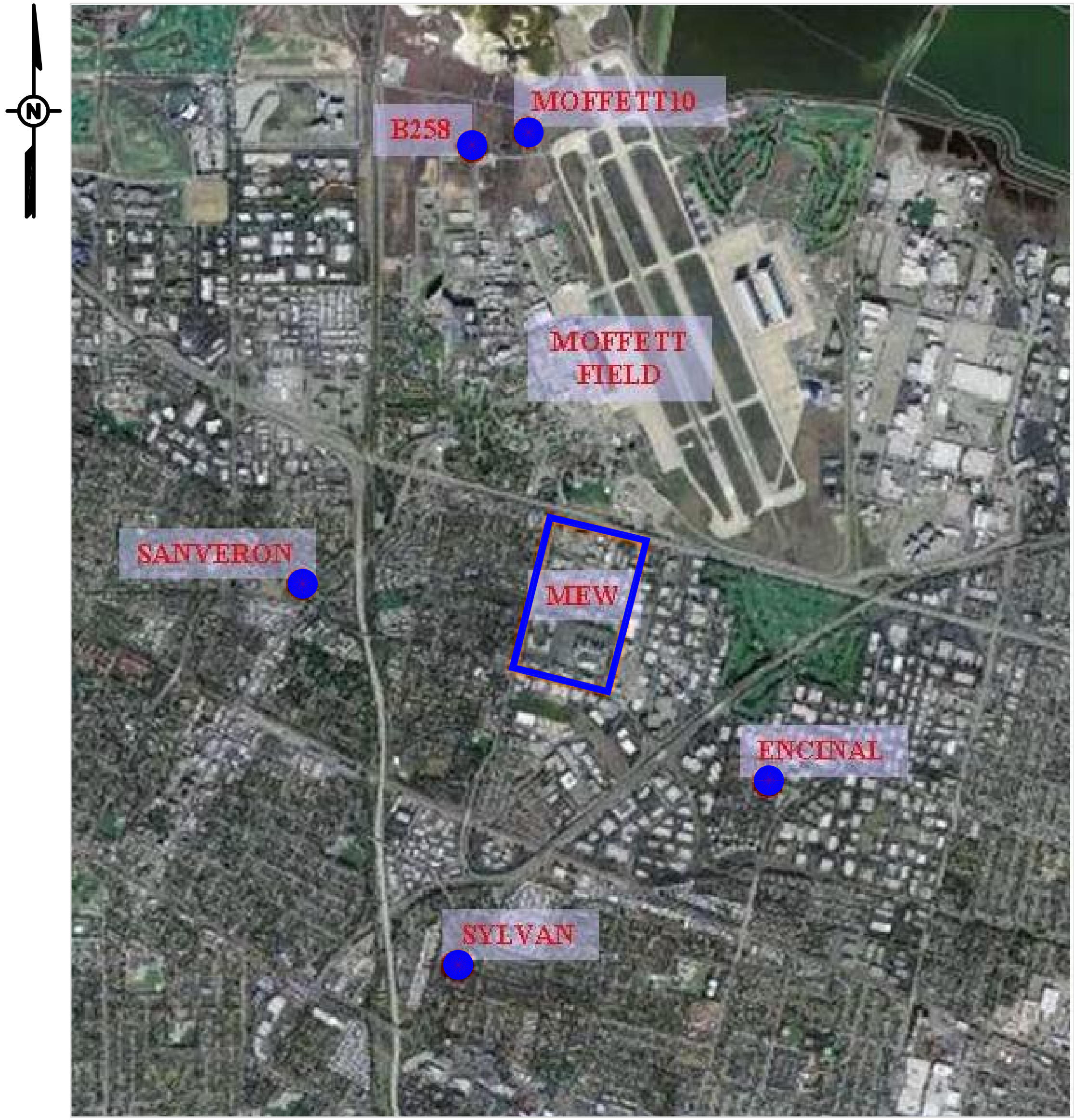

LEGEND:

BACKGROUND SAMPLE LOCATION

BACKGROUND SAMPLE LOCATIONS

PREPARED FOR

MEW COMPANIES

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
2	29 SEP 06	ISSUED FOR REPORT	VZC	CNN	JDR

Locus TECHNOLOGIES

SCALE: N T S

DRAWING NO. 23-007-A131

FIGURE 5-2

K:\23-007\A131.DWG 11 AUG 06

Notes:
AL – action level (TCE AL = 5 ug/m^3 for commercial; 1 ug/m^3 for residential)
HVAC – heating, ventilation & air conditioning system
ICs – institutional controls (may vary with each Tier)
OUT – outdoor air
[1] Defined as groundwater TCE or PCE concentration <100 ppb for commercial areas and <50 ppb for residential areas. Or vinyl chloride concentration < 20 ppb in commercial areas or <10 ppb in residential areas.

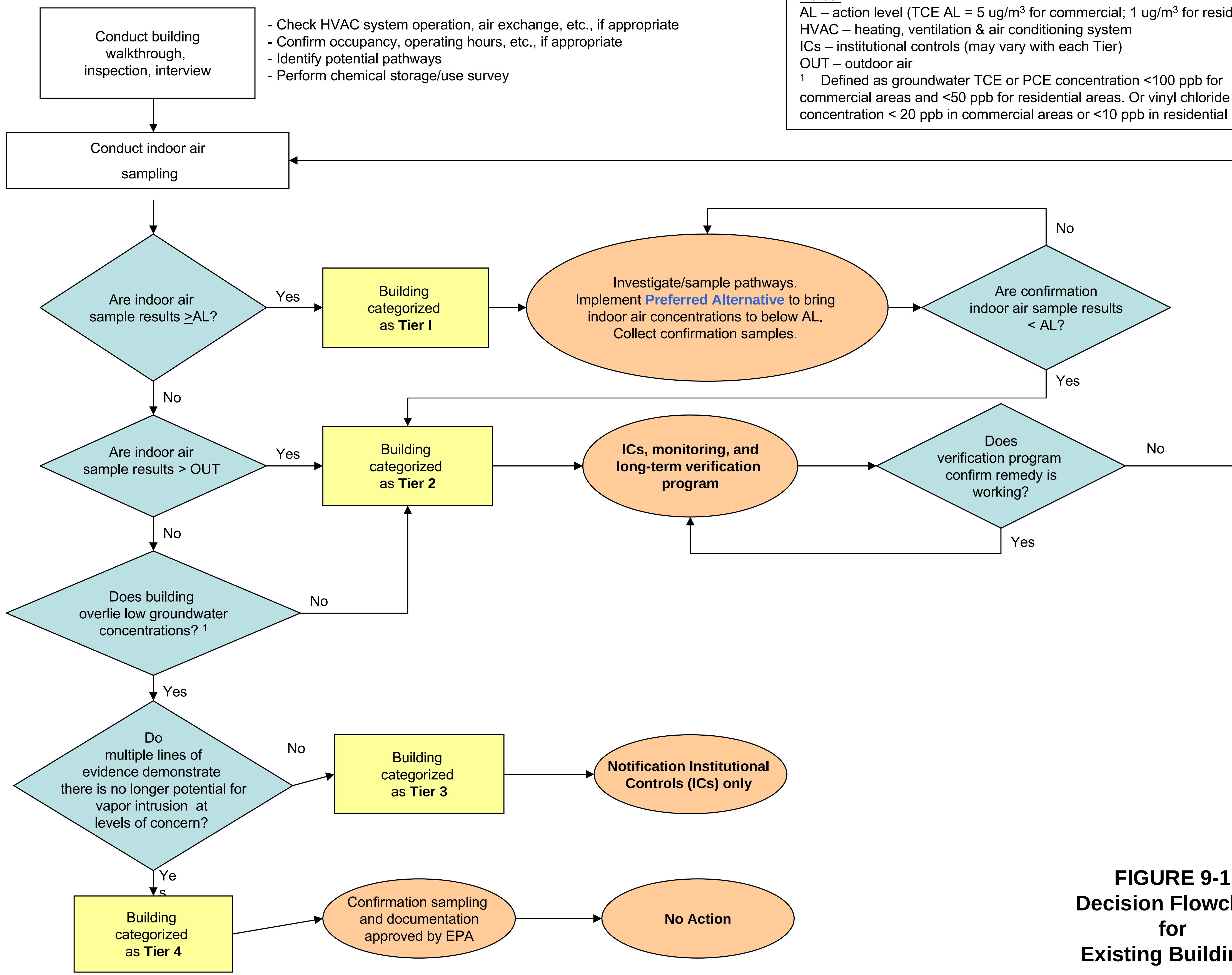

FIGURE 9-1
Decision Flowchart for Existing Buildings

Notes:
ppb – parts per billion, or micrograms per liter

1. For commercial or multi-family residential buildings constructed with aboveground raised foundations, see Table 9-2.
2. Defined as groundwater TCE or PCE concentration <100 ppb for commercial areas and <50 ppb for residential areas. Or vinyl chloride concentration < 20 ppb in commercial areas or <10 ppb in residential areas.

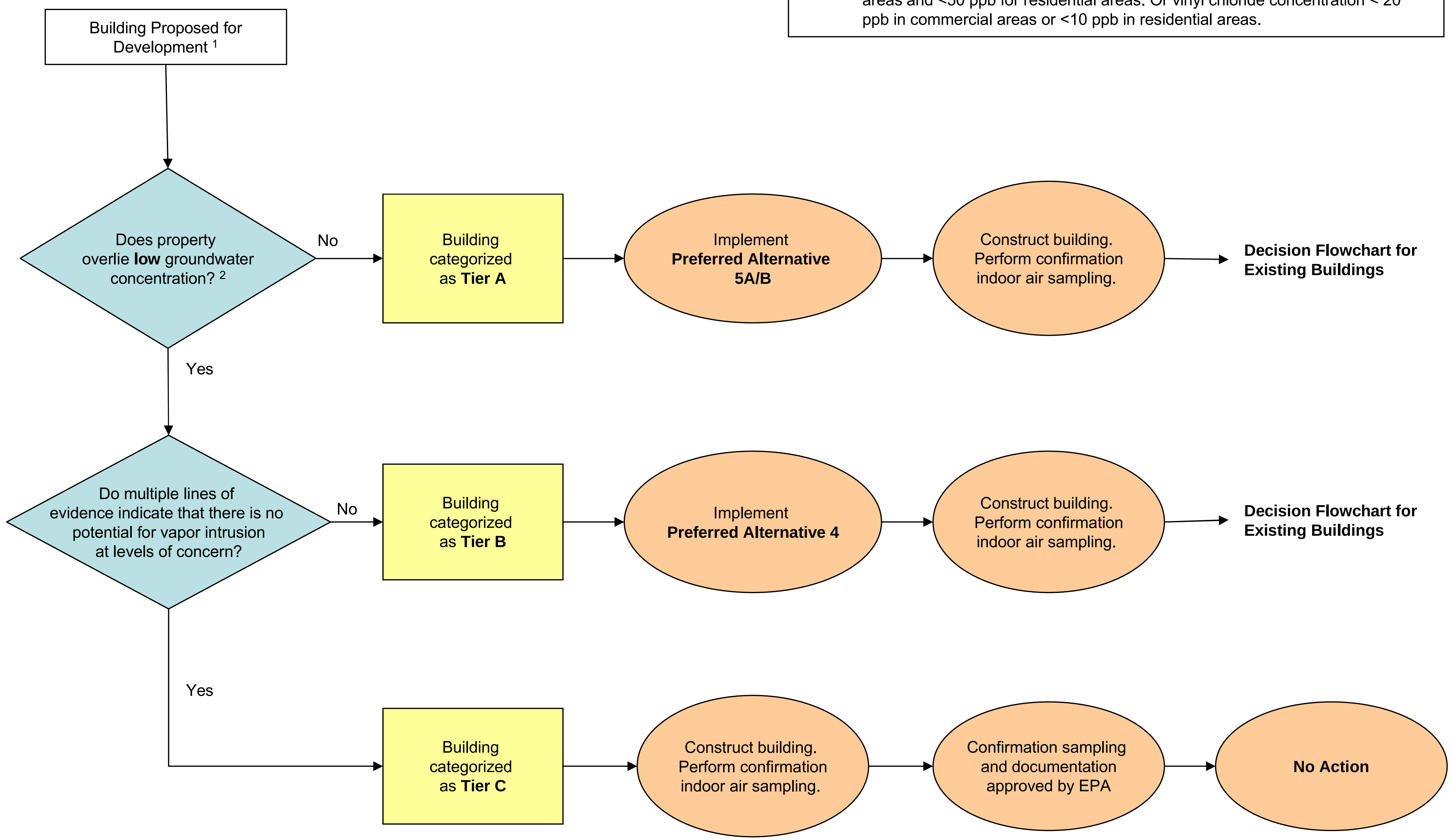

FIGURE 9-2
Decision Flowchart for Future Buildings

APPENDIX A

RESPONSE TO EPA COMMENTS ON DRAFT SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION

APPENDIX A

RESPONSES TO EPA COMMENTS ON DRAFT SUPPLEMENTAL FEASIBILITY STUDY FOR VAPOR INTRUSION MIDDLEFIELD-ELLIS-WHISMAN STUDY AREA, MOUNTAIN VIEW AND MOFFETT FIELD, CALIFORNIA

EPA General Comments

General Comment 1: Basis for Supplemental FS

EPA disagrees with the conclusion of the Draft Supplemental RI Report (Draft RI Report) and re-stated throughout the Draft Supplemental FS Report (Draft FS Report) that vapor intrusion at levels greater than EPA's long-term exposure goals may occur only under limited conditions. In fact, the Draft RI data indicates that the subsurface vapor intrusion (VI) pathway is complete in a number of buildings that exceeded EPA's interim action levels for long-term exposure. Based on the available data collected to date at the Middlefield-Ellis-Whisman (MEW) Site, there is the potential for vapor intrusion into all buildings overlying shallow subsurface volatile organic compound (VOC) contamination at concentrations exceeding EPA's levels of concern for long-term exposure. Therefore, the FS is needed to evaluate potential remedial action alternatives to address the vapor intrusion pathway to ensure that building occupants are protected from Site contamination.

Response: Please refer to the response to RI comments (EPA Specific Comment 3 on the draft RI report). The data collected during the RI phase demonstrated that vapor intrusion resulted in indoor air concentrations of VOCs higher that EPA's long-term exposure goals only under unique conditions. Based on the responses to comments to the draft RI report, Sections 1.1 and 2.2.3 and the introduction to Chapter 3 of the Draft Supplemental FS will be revised to retain reference to deep vaults but remove the special condition of the vault intercepting the groundwater. Although no data were collected in such situations, the reference to vaults intercepting the groundwater will be removed for conservative reasons. The RI already refers to the special situation of NASA Building N210. The aforementioned sections will be revised to reference the unique HVAC setting of NASA Building N210.

The MEW Companies and NASA have and will continue to conduct walkthroughs in buildings to identify such unique situations. Interim remedies have been implemented when these situations have been encountered. Further, should such situations be encountered in the future, the Draft Supplemental FS provides the mechanism for implementation of an appropriate remedy.

Regarding the last sentence in the comment above, the Draft Supplemental FS does evaluate potential remedial action alternatives and provides a versatile menu of alternatives applicable to existing and future residential and commercial developments in the Study Area.

<u>General Comment 2: Additional Remedial Action Objectives Needed</u>

The Draft FS Report recommends one Remedial Action Objective (RAO) for the vapor intrusion pathway: to reduce levels of trichloroethene (TCE) and other Site-related contaminants of concern in air within affected buildings attributable to the vapor intrusion pathway to levels protective of building occupants (both workers and residents), provided these levels are not below background. There are several other RAOs that should be included in the Revised FS Report for the vapor intrusion remedy.

- **To prevent Site contaminants in soil gas at levels of concern from migrating into indoor air (e.g., cut off the VI pathway before entering building)**

- **To prevent or reduce accumulation of Site contaminants in enclosed building spaces at levels of concern to ensure that building occupants are protected from Site contamination.**

In addition, EPA recognizes that there are two feasibility studies underway at the MEW Site: this Draft FS Report that specifically addresses the vapor intrusion pathway and a Site-wide Focused FS currently being prepared for the Regional Groundwater Remediation Program. One of these FS Reports must include the following RAO:

- **To reduce the mass and concentrations of Site contaminants in groundwater/soil/soil gas to be protective of the building occupants from contamination entering indoor air via the subsurface vapor intrusion pathway.**

<u>Response:</u> The first RAO suggested by EPA is not achievable. As discussed in the Draft Supplemental FS, it is not practical in most existing buildings to "cut off the VI pathway before entering the building", as this would require a technology such as SSD, SSP, vapor barriers, that cannot be implemented in most existing buildings in the Study Area. Further, this RAO is not necessary when the RAO proposed in the Draft Supplemental FS is in place.

The second RAO suggested by EPA seems to be redundant with the one proposed in the Draft Supplemental FS.

Discussion of third RAO suggested in the comment above will be deferred to Site-wide Focused FS report that is being prepared for the Regional Groundwater Remediation Program. However, as discussed in the Draft Supplemental FS report on vapor intrusion, it is not possible to reduce in a reasonable time frame the concentration in groundwater to levels below which vapor intrusion is not a potential concern.

<u>General Comment 3: Need to address Vapor Intrusion Source</u>

The Draft FS Report eliminated subsurface contaminant removal technologies (e.g., soil vapor extraction and groundwater remediation technologies) as a recommended alternative for the VI remedy. The Draft FS Report should be revised to clarify that the proposed alternatives are limited to those that will address reducing indoor air concentrations, cutting off or preventing the VI pathway, and preventing human exposure to Site contaminants at levels of concern for long-term exposure.

<u>Response:</u> Sections 6.4 and 8.1 (now Section 9.1 of the revised FS) will be revised to add the clarification suggested in the comment above.

<u>**General Comment 4: NASA's Environmental Issues Management Plan**</u>

The vapor intrusion mitigation alternatives presented in NASA's Environmental Issues Management Plan (EIMP) (March 2005) and Preliminary Regulatory and Cost Evaluation of Alternative Approaches to Vapor Intrusion Mitigation for NASA Research Park (July 2004) should be used as a model for the "menu" approach to applying the VI remedy to existing and future buildings overlying the shallow regional groundwater contamination. The Draft FS Report should be revised to incorporate the alternatives provided in the EIMP and those alternatives should be considered among the remedial alternatives for the VI remedy. The Revised FS Report should also discuss how the vapor intrusion mitigation alternatives in NASA's EIMP could be incorporated as part of the VI remedy for the applicable buildings on Moffett Field.

<u>Response:</u> It is our understanding that EPA asks for additional information on the remedies to facilitate generation of the proposed plan. Accordingly, Section 8.2 of the Draft Supplemental FS (now Section 9.2 of the revised FS) will be revised to provide the additional information.

NASA has participated in the Draft Supplemental FS process and endorses its findings and recommendations. Data generated by NASA on Moffett field are included in the evaluations and were used to select remedies in the Draft Supplemental FS. NASA will be amending its 2005 EIMP to reflect that the vapor intrusion portion of the EIMP is superseded by the Supplemental FS. Remedial measures found in the EIMP were considered in the Draft Supplemental FS. Chapter 8 will be revised to reference the EIMP and to reflect that the FS will supersede it.

<u>**General Comment 5: No Further Action Inappropriate for Residential Areas**</u>

EPA does not agree with the proposal in the Draft FS Report that the remedy in the residential area west of Whisman Road be "no further action." Groundwater and air data have shown that there is the potential for vapor intrusion in areas overlying low levels of groundwater contamination (i.e., TCE at concentrations ranging between 5 and 100 micrograms per liter [μg/L] in the western residential groundwater plume areas). Elevated TCE concentrations in indoor air exceeding EPA's interim action level of 1 microgram per cubic meter ($\mu g/m^3$) of TCE in indoor air have been found at Residence 4 and former Wescoat Housing units 620E and 620F. Mitigation measures have been implemented at Residence 4 and at the entire new residential development at the Wescoat Housing Area (Wescoat Village) to ensure that TCE in indoor air at levels of concern are reduced. Therefore, at a minimum, long-term monitoring of these areas and institutional controls are necessary to ensure that current residences and future residences in this area are protected from the potential vapor intrusion pathway.

<u>Response:</u> Section 8.4 (now 9.3 of the Revised FS) will revised to indicate that a monitoring plan will be developed. Chapter 8.0 of the Revised FS will discuss institutional controls.

<u>**General Comment 6: Additional Monitoring Needed In Residential Areas**</u>

The Draft FS Report should be revised to evaluate installation of additional groundwater monitoring wells, soil gas monitoring, and/or indoor air monitoring for residential areas to ensure the long-term protectiveness of residents in homes overlying subsurface contamination in these areas. For new residential construction, the Revised FS Report should evaluate use of engineering controls as a cost-effective mechanism to address the potential vapor intrusion pathway and ensure long-term protectiveness. In addition to the engineering controls, appropriate institutional controls should be evaluated.

Response: In 2007, the MEW Companies added three monitoring wells to the groundwater monitoring network in the residential area West of Whisman Road. Long-term monitoring of wells in the area has shown that 1) the plume has not expanded in a westerly direction, and 2) the VOC concentrations are decreasing. As expected, on-going remediation of the groundwater plume will result in further decrease in groundwater concentrations, and therefore, less potential for vapor intrusion.

Per General Comment 8 (see below), additional information will be added to the "General Verification/Monitoring Plan" section. Also, Chapters 6 and 7 will be revised to include "monitoring" as an alternative.

The Draft Supplemental FS provides alternatives for future residential constructions. However, in the area west of Whisman Road, data collected from 17 residences have shown that engineering controls are not needed unless, possibly, if a house is constructed with a basement or earthen cellar. In that case, the Draft Supplemental FS provides remedies for future residential construction if a basement is needed. Finally, the Draft Supplemental FS will be revised to include provisions for institutional controls that complement remedial alternatives.

General Comment 7: Cost Analysis – New vs. Existing Buildings

The cost for implementing a vapor intrusion remedy in new construction is generally far less than in existing buildings. For example, with a newly constructed building, it may be more cost-effective to incorporate mitigation measures such as a vapor barrier and passive or active sub-slab ventilation system into the building design rather than relying solely on a heating, ventilation, and air conditioning (HVAC) system and its associated monitoring and long-term operational agreements. In order to properly evaluate remedial costs for each alternative, the cost analysis for the existing and newly constructed buildings should be presented separately.

Response: We agree that the cost for implementing a vapor intrusion remedy in new construction is generally less than in existing buildings. In the detailed analyses of alternatives, Chapter 7 differentiates costs for alternatives for existing and future buildings when the alternative is applicable to both scenarios, and when such differentiation is appropriate. For example, when the cost of the alternative is the same in existing and new buildings, one cost value is provided. For example, Section 7.2.2 of the Draft Supplemental FS (now Section 7.2.3 of the Revised FS), Sub-slab Depressurization, stated the following (emphasis added):

> Cost
>
> For **new** construction, an estimated cost for a sub-slab depressurization system for a 20,000 square-foot building may range between $103K and $123K, with an estimated 30-year present worth for O&M of $274K. O&M costs would include electrical costs, system maintenance, and replacement of the blower. For an **existing** commercial building, the cost is estimated to range between $133K and $221K, with a 30-year present worth for O&M costs that may range between $274 and $457K, depending on the number of depressurization nodes used.
>
> For a 2,000 square-foot residence, the cost for a **future** residence may range between $3K (for a single depressurization node) and $21K for a gravel layer equipped with a depressurization blower. For an **existing** residence that would typically use one depressurization node, the cost may vary between $3K and $7K. The estimated 30-year present worth for O&M costs is about $7K, which includes electrical costs and the blower replacement.

Section 7.2.14 (now Section 7.2.15 of the Revised FS), Soil Vapor Extraction, stated the following (emphasis added):

> Cost:
>
> For a **future** building where a system can be installed and piped before construction of the building, the estimated capital cost for an SVE system, assuming 25 vertical wells at 30-foot centers, is $293K. The estimated 30-year present worth of annual O&M costs is $1,140K, which includes sampling, reporting, electrical, and vapor treatment costs.
>
> To install an SVE system under an **existing** 20,000 square-foot building, the estimated capital cost assuming horizontal wells varies between $333K and $414K, assuming normal access. The estimated 30-year present worth of annual O&M cost is as described above.

Similarly Tables 7-2 and 7-3 separate costs for existing and future buildings when applicable (see for example sub-slab depressurization costs and vapor extraction costs).

For the other alternatives in Chapter 7, a description that there are not significant differences in costs between future and existing buildings, or that the alternative is applicable only to future buildings, will be added. In addition, the comment section in Tables 7-2 and 7-3 were revised to add the aforementioned explanation.

General Comment 8: Confirmation Sampling and Long-term Monitoring

To date, several interim actions have been implemented and shown to be effective in reducing contaminant concentrations. Also, various remedial action alternatives to address the vapor intrusion pathway are proposed for the MEW Site in the Draft FS Report. For each of these alternatives, confirmation sampling is required to ensure that the remedy is functioning effectively to achieve RAOs. Additionally, to ensure the ongoing protectiveness of the remedy, a long-term monitoring plan is required to periodically verify that there are no additional remedial actions that are necessary.

Response: Please refer to responses to General Comments 5 and 6. Section 8.4.3 of the Draft Supplemental FS (now Section 9.4 of the revised FS) will be modified to include sampling as one way of monitoring the remedy. In addition, Section 8.4.3 will be revised to include provisions for a long-term monitoring plan that will be prepared after approval of the Draft Supplemental FS report.

General Comment 9: Proposed Ventilation Criteria Do Not Eliminate the Need for TCE Confirmation Sampling

The Draft FS Report should be revised to include the costs for confirmation air sampling for all buildings including the mechanical ventilation alternative as well as other alternatives to ensure the mitigation approach is effective. The Draft RI Report did not demonstrate that mechanical ventilation alone is effective in reaching the TCE indoor air goal for all buildings. The approach that has been demonstrated to be effective in the short-term for existing buildings is one that combines mitigation actions (e.g., sealing conduits, mechanical ventilation, rearranging the duct system and installing an air purification system) with indoor air testing. EPA does agree that the data collected to date supports a decision to do no further indoor air testing for TCE and other VOCs if a building air exchange rate is estimated to be one per hour (1/hr), which appears to be the proposal in the Draft FS Report. Focusing only on one component instead of the overall approach

that has been demonstrated to be effective for existing buildings is not supported by the evidence. Moreover, the estimates of air exchange alone (without considering air balancing) do not take into account whether the air would actually be delivered to individual occupied rooms and spaces at an air exchange of 1/hr. The Draft FS Report should be revised to address these points.

Response: The RI provides building-by-building analyses of air samples in Chapter 4, and provides an overall statistical approach of the air sampling results in Chapter 5. Based on the sampled buildings, the RI concludes that using an air exchange rate of 1/hr is appropriate for the ventilation remedy. In the remainder of this general comment (below), EPA offers examples of buildings where EPA believes the screening level did not work. The responses below provide clarifications why these buildings are not an exception to the rule.

The conclusions of the Draft RI Report do not support specific ventilation criteria or support a conclusion that TCE sampling measurements are unnecessary. The Draft RI Report states on page 88 that "no clear demarcation of an acceptable exchange rates that results in a TCE concentrations below the interim action level of 2.7 μg/m^3 can be determined based on the data collected to date. NASA also conducted tests in which the percent of makeup air was reduced in ten percent increments from 100% to 30% and TCE concentrations were measured over an eight-week period (NASA 2005b). Low TCE air concentrations were measured but NASA concluded that the measured concentrations did not correlate well with the recorded percent make-up air data." These conclusions do not support the use of specific ventilation criteria such as make-up air or air exchange as a substitute for actual TCE measurements.

Response: The ITRC states that "the initial investigation can center on the worst-case buildings, with subsequent rounds of sampling targeting adjacent buildings" (ITRC 2007a). During the RI process, buildings over the highest groundwater concentrations were sampled, and unique conditions were developed to identify "worst case" buildings. The worst-case scenario is not necessarily buildings over the highest concentrations in the groundwater, but also could be buildings that could have basements, a low air exchange rate, or conduits that may serve as preferential pathways.

In response to EPA's observation that NASA could not find a good correlation between measured concentrations and makeup air, EPA is referring to Building 15 in which NASA attempted to correlate indoor air concentrations with make-up air when NASA attempted to reduce the makeup air in 10% increments from 100% to 30%. Subsequent to EPA's comment above, Locus asked for clarification from NASA. Ms. Sandy Olliges explained in a telephone call to Locus on 7 January 2008 and a follow-up email that when NASA adjusted the HVAC controls to increase the per cent makeup air, the speed of the fan in the HVAC unit automatically lowered, keeping the air exchange rate constant. Consequently, it was not possible to obtain a relationship between concentrations and makeup air because the makeup air remained virtually constant. NASA did not realize that this had occurred until after the sample data were analyzed. Consequently, it was not possible to obtain a relationship between concentrations and makeup air because the air exchange rate remained virtually constant.

The statement in Section 7.2.7 of the FS Report that "air sample results demonstrate that all buildings with an air exchange rate of at least 1/hr showed TCE concentrations significantly lower than the long-term commercial exposure goal of 2.7 μg/m^3 for both air-tight buildings and leaky buildings" is misleading. It would not be correct to state that all TCE concentrations in all buildings with an air exchange rate greater than 1/hr were below the long-term exposure goal without qualifying the statement to exclude certain rooms within the building, certain pathway samples

within the building, and individual TCE results that the Draft RI and FS Reports describe as "anomalous", "inconsistent", or "unconfirmed".

Response: Please note that both the Supplemental Draft RI and FS documents identify samples that were anomalous, inconsistent with previous and subsequent samples collected at the same location, or unconfirmed by duplicate samples. These do not change the conclusions of the Supplemental Draft RI and FS regarding using an air exchange rate of 1/hr as a screening level for proper ventilation in a building.

Air sampling measurements have been invaluable not only in confirming the vapor intrusion pathway is complete into buildings at the Site but also providing feedback when optimizing building-specific mitigation measures in a number of buildings. Examples include:

- **Residence 4. For this residential building, a decision to reverse air flow to optimize the ventilation system would not have been performed if TCE confirmation air sampling had not been collected.**

- **401 National Avenue. This building meets the 1/hr criteria but required additional mitigation measures (sealing cracks and penetrations in utility room, reconnecting the existing exhaust fan to the building's electrical power source and installing ducting to enhance ventilation in the interior portions of the building) to meet the TCE interim action level.**

- **644 National Avenue. In response to measured TCE indoor air sample results, the elevator shaft and openings in the basement floor were sealed and two exhaust fans were installed in the basement. Air sampling measurements subsequently indicated (based on preliminary information) that the elevated TCE concentrations in the basement could be isolated from the upper floors when sufficient air was exhausted from the basement.**

- **501 Ellis Street. This building air exchange meets the 1/hr ventilation criteria but required follow-up mitigation activities based on TCE air sampling results. Follow-ups included evaluating the HVAC system operation, checking the office in the southeaster portion of the building for additional slab penetrations, sealing the fire sprinkler test system drain with a plug, and sealing two pipes in the southeast office with sealing foam.**

- **370 Ellis Street, Building A. This building meets the 1/hr criteria during the weekday. However, additional follow-up activities were necessary to reduce levels in the utility rooms. The TCE air sampling results indicated that the subsurface vaults are a possible TCE source and consequently the conduits connecting the utility rooms to the outside vaults were sealed. TCE air samples collected after sealing the conduits in the utility room indicated a substantial reduction in TCE concentrations but still at above the TCE air goal. Based on the TCE air sample results, additional measures were taken, including installing an air purification system in the room and collecting a series of TCE confirmation air samples.**

- **380 Ellis Street, Building C. This building meets the 1/hr criteria during the weekday. The mitigation / testing approach taken for this building is similar to 370 Ellis Street, Building A.**

- **380 Ellis Street, Building D. The mitigation / testing approach for this building is similar to 370/380 Ellis Buildings A/C. However, based on the preliminary TCE results, an air**

purification system was not deemed to be necessary to meet the TCE goal in the utility rooms.

- **<u>350 Ellis Street, Building E.</u> The mitigation / testing approach for this building is similar to 370/380 Ellis Buildings A/C. However, based on the preliminary TCE results, an air purification system was not deemed to be necessary to meet the TCE goal in the utility rooms.**

- **<u>425 National Avenue.</u> This building is currently vacant and a HVAC system has been installed. Confirmation air sampling is needed to confirm if TCE concentrations have been reduced to meet the TCE goal.**

- **<u>NASA Building 16</u>. TCE air measurement results prompted the sealing of conduits and installation of an HVAC system.**

- **<u>NASA Building N210.</u> TCE measurements were critical to determining that mechanical ventilation alone was insufficient to reduce the TCE concentrations in this building. Follow-up activities determined that building ventilation appeared to enhance vapor intrusion into the workspace. The solution apparently was to rearrange the duct system so that the air is supplied through a network from the ceiling. Also, all grates in the "subfloor "were replaced with solid floor tiles and all protrusions through the existing floor tiles were sealed.**

- **<u>670 National Avenue.</u> TCE test results indicated elevated TCE indoors even though the HVAC system was operating. An analysis of the HVAC system revealed that certain HVAC units were not operating.**

<u>Response:</u> The following is an itemized list of notes on the comments regarding the buildings listed above.

401 National Avenue: Please note that this building does not meet the 1/hr air exchange rate screening. The supplemental RI (Section 4.3.1.7) explains that the HVAC system could be operated for only 1.5 hours.

501 Ellis Street: Please refer to the language in Section 3.4 of the draft Supplemental FS Report, which correctly describes the remedial measures implemented at 501 Ellis Street.

370 Ellis Street Building A: To clarify, please note that the utility rooms are not ventilated to the outside.

380 Ellis Street Buildings C and D: Please see above.

350 Ellis Street Building E: Please see above.

Building 16: Using the criteria established in the response to the first part of this general comment, this building would have been selected for sampling. Also please note that an HVAC system has not yet been installed in Building 16.

670 National Avenue: See note on Building 16.

General Comment 10: Evaluation of Potential After-Hours Exposure

The discussion of risk for after-hour exposures (Section 5.3.5, page 28) does not follow Risk Assessment Guidance for Superfund because it lacks a reasonable maximum exposure (RME) estimate of after-hour exposures/risks. Superfund risk decision-making is based on a projected maximum exposure case (that is reasonably anticipated) and not an average estimate of exposure, which appears to be closer to the estimates described. For example, the Draft FS Report uses the median occupational tenure of 4.2 years for janitorial and maintenance staff. The median value represents a case where 50% of this population of workers would still be present at their job after 4.2 years. Therefore, the median case would not be consistent with Superfund RME. Exposure factors that are consistent with the Superfund RME for indoor workers are described on page 26 of the Draft FS Report. Refer to this section of the Draft FS Report when evaluating indoor workers. In addition, the use of average concentrations as described on pages 28-29 of the Draft FS Report and the pooling and averaging of TCE data across buildings with varying indoor air quality does not follow Superfund guidance for estimating an exposure point concentration term consistent with an RME. In general, an RME estimate would use a maximum concentration or if sufficient data were available, an upper confidence limit on the average concentration (95UCL). From EPA's perspective, the discussion of after-hour exposures is inconsistent with Superfund's RME approach and tends to discount potential after-hour exposures.

EPA still has concerns with respect to how the MEW Companies plan to address after-hour exposures. Further attention should be paid to this issue when describing overall protection of human health in the detailed analysis of remedial alternatives in the Revised FS Report.

Response: The Supplemental Draft RI and FS do not intend to discount after hours workers. The Draft Supplemental FS presents a realistic representation of exposures that are not full time long-term exposures: professional workers do not work 9.5 hours per day each weekend day and janitorial staff do not spend 9.5 hours each day in the same building.

Unfortunately, the EPA Exposure Factors Handbook does not provide data for an upper percentile duration of exposure for all occupations. Even if data for maximum values were compared with the 2.7 value, there are only two maximum values that exceed the 2.7, with the highest degree of exceedance being about 3-fold for the maximum value of 8. When UCLs from these data (calculated by building in table provided) are considered only one UCL (for the data set with the detection of 8) is above 2.7, and it is a value of 3.2. Considering that workers do not spend 25 years within one

Calculation of 95 percent upper confidence limits on means for buildings

Building	Number of samples	Average Concentration (maximum) ug/m^3	UCL for Building (number of samples) ug/m^3
370 Ellis Street Bldg. A (May 2003)	8	1.54 (3.7)	2.3 (16)
370 Ellis Street Bldg. A (September	8	0.82 (2.6)	
370 Ellis Street Bldg. B (May 2003)	8	1.36 (2.7)	3.2 (16)
370 Ellis Street Bldg. B (September	8	2.71(8)	
380 Ellis Street Bldg. C (May 2003)	8	0.38(0.97)	0.91 (32)
380 Ellis Street Bldg. C (September	8	0.61(2.8)	
350 Ellis Street Bldg. E (May 2003)	8	0.34(0.71)	0.435 (16)
350 Ellis Street Bldg. E (September	8	0.19(0.64)	

building, and do not spend their entire time at the location of any one sample, the finding of a UCL that is 1.2 times the target suggests that risks are within acceptable levels. Although the 95th percentile of duration within the janitorial and cleaning occupations is not known, the median is known to be 4.2 years.

Section 5.3.5 of the Draft Supplemental FS will be revised to include the additional calculations above.

General Comment 11: Long-term Monitoring/Assessment Alternative

EPA anticipates that long-term monitoring or additional characterization may be necessary for certain portions of the Site that are not under active mitigation or in areas that are mixed with some buildings demonstrating vapor intrusion issues while others do not. Building owners in the future may also request that their property or building be sampled to demonstrate that vapor intrusion is not occurring. A long-term monitoring / assessment option should be included in the discussion of remedial alternatives.

Response: Please see response to General Comments 5 and 6.

General Comment 12: Sub-Slab Passive Ventilation

While the sub-slab passive ventilation systems are promising (in conjunction with vapor barriers) there is only limited data on the effectiveness of this system and its ability to perform under both residential and commercial building conditions. Additional verification of sub-slab passive ventilation systems under conditions is recommended to confirm its short-term and long-term effectiveness. The Wescoat Village development overlies (or, is within 100 feet of the edge of the shallow groundwater contaminant plume) where TCE concentrations are relatively low compared to other areas of the groundwater plume.

If an active sub-slab/sub-membrane ventilation system is necessary for a particular building, then EPA may require additional sampling testing to establish that a passive system was also effective in mitigating the VI pathway. Active sub-slab ventilation systems are typically recommended in EPA's radon program because they have been demonstrated to be more effective than passive systems at mitigating radon intrusion. The Draft FS Report should take into account that passive ventilation systems could incur additional costs associated with increased indoor air testing that EPA may require to verify that a passive system provides a comparable level of protection as that of an active system.

Response: The draft Supplemental FS included provisions for indoor air sampling in Tables 7-2 and 7-3, as well as in section 7.2.5 -Vapor Barriers and Sub-Slab Passive Ventilation (now Section 7.2.6 of the Revised FS). However, per responses from previous comments, Tables 7-2 and 7-3 will be revised to include costs for air sampling for all monitoring. These costs are used only to compare costs of alternatives. As stated in the responses to General Comments 5 and 6, a monitoring plan will be submitted to EPA after approval of the Draft Supplemental FS.

The costs assume that sub-slab passive ventilation may require more indoor air testing.

General Comment 13: Technology Screening

The Draft FS Report should also include remedial technologies for buildings with crawlspaces and basements. Although the FS cost estimate is plus 50% minus 30%, the presentation is very difficult to follow.

<u>Response:</u> The Draft Supplemental FS provided remedial technologies for both basements and crawlspaces. For example, for existing buildings, remedies for basements may include sub-slab depressurization systems (Section 7.2.3 – now 7.2.4 of the revised FS), mechanical ventilation (Section 7.2.7 – now 7.2.8 of the revised FS), or surface coatings/vapor barriers (Section 7.2.10 - now 7.2.11 of the revised FS). For future buildings other alternatives are applicable as well, as long as the basement is not under the water table.

Crawlspaces are a form of raised foundations (Section 7.2.11). Additional language will be included in the revised Draft Supplemental FS (Section 7.2.11 is now 7.2.12 in the revised FS) to clarify application of alternatives to basements and crawlspaces.

Regarding the last sentence, please refer to response to General Comment 7.

EPA Specific Comments

<u>**Specific Comment 1: Page 2, Section 1.1 Reasons for a Supplemental Feasibility Study**</u>

The Draft FS Report does not accurately reflect the reasons EPA required that the FS be conducted. EPA has determined that there is a potential for vapor intrusion into all buildings overlying the shallow groundwater contamination (within 100 feet of the estimated TCE regional groundwater contamination plume boundary). After evaluating approximately 40 commercial buildings overlying the plume, EPA has concluded that there are buildings where TCE is entering from the subsurface at indoor air concentrations exceeding EPA's levels of concern for long-term exposure. In exploring various ways to address the vapor intrusion pathway, certain mitigation measures were evaluated. The FS is intended to identify and evaluate a range of alternatives to ensure that VOCs in indoor air from the subsurface do not exceed EPA's long-term indoor air quality goals.

The Draft FS Report asserts that most buildings at the Site do not exceed long-term indoor air quality goals and that vapor intrusion occurs only under limited conditions. First, nearly half of the buildings overlying the shallow groundwater contamination have yet to be sampled. Second, it is EPA's position that vapor intrusion is occurring in many of the buildings and action is necessary to prevent the levels from exceeding long-term indoor air quality goals.

<u>Response:</u> In response to the first comment, language from EPA's 8 March 2006 letter requesting a supplemental RI/FS for vapor intrusion will be included in Section 1.1.

Regarding the second portion of this comment, Section 1.1 will be revised to specify that vapor intrusion <u>*resulting in indoor air concentrations exceeding long-term exposure goals*</u> may occur under limited conditions. The section will also specify that most <u>*sampled*</u> buildings at the site did not exceed long-term exposure goals.

<u>**Specific Comment 2: Page 10, Section 2.2.6 Data Analyses and Findings**</u>

The text indicates that "TCE concentrations" are reported to be "reduced after implementation of discrete remedial measures (i.e., sealing conduits), but the effects are less evident when ventilation is operating in these buildings". It appears the Draft FS Report might be underestimating the remediation effects of other measures, including sealing conduits. It is most important to utilize all the remediation technologies available, as well as their combinations, while applying them cost-effectively. While ventilation measure might be effective, the annual operations, maintenance and monitoring expenses associated with mechanical ventilation systems are likely higher than that of other measures and, even more importantly, the mechanical ventilation effectiveness is contingent on its continuous operation during building occupancy, which is not addressed in the Draft FS Report.

<u>Response:</u> The Draft Supplemental FS provides a detailed evaluation of several remedial measures, including sealing of conduits and mechanical ventilation. The Draft Supplemental FS does not underestimate remediation effects of one measure over the other, unless a remedy is discounted by data. In fact, the Draft Supplemental FS recommends not one, but a list of remedial alternatives that could be applicable for existing and future residential and commercial buildings. Both mechanical ventilation and sealing of conduits are on the list. In fact, Section 7.2.8 (now Section 7.2.9 of the revised FS), which

provides a detailed evaluation of sealing of conduits states that "[s]ealing of conduits resulted in significant reductions in indoor air concentrations when these conduits provided a direct pathway for VOCs from the subsurface." As such, it was retained as one of the alternatives retained when conduits provide such pathway.

In addition, we also agree with EPA's statement above that it is "important to utilize all the remediation technologies available, as well as their combinations, while applying them cost-effectively". This approach has been implemented at the Site in utility rooms where sealing of conduits resulted in a significant decrease in concentrations, but not to below long-term exposure goals. Although these utility rooms are not occupied, and exposure is limited, air purification systems were installed to reduce the concentrations to below long-term exposure goals.

Regarding the second portion of the comment on costs of ventilation and its operations, these are addressed in the Draft Supplemental FS in the cost sections and in the detailed evaluation of the remedy. In addition, the Draft Supplemental FS will be revised to include more detailed descriptions of institutional control measures (Chapter 8 of the revised FS).

Specific Comment 3: Section 5.1 Background and Indoor Air Concentrations

Summary statistics (page 22) should be provided for the most recent BAAQMD station at Whisman Park. These data collected during 2004 / 2005 are more recent than the data for the BAAQMD station that is reported. The BAAQMD results (collected in the 1990's) are not necessarily an appropriate comparison due to the downward trend indicating declining outdoor air concentrations for TCE and other contaminants in the past 20 years.

Response: A range of TCE concentrations for the BAAQMD temporary station will be added to the text in Section 5.1. Please note that the RI does not use the results of the former BAAQMD station at Cuesta Drive, but it does include the results of the more recent temporary station at Whisman Park.

Specific Comment 4: Page 26-27, Section 5.3.2 Current Status of the EPA Draft TCE CSFs

The statement that "*These CSFs are based predominantly on studies where the route of exposure was oral. The upper-end value of the draft TCE CSFs is based on an epidemiological investigation of a population with oral exposure to TCE and other chemicals in drinking water*." is incorrect. Most of the human epidemiological studies were based on worker studies where exposure to TCE occurred primarily via the inhalation route. And, the highest estimated CSF (see Figure 4-3, page 4-43 of EPA's Draft TCE assessment) was based on inhalation exposures in the Finnish workers study. Therefore, EPA recommends that this comment be deleted, as it appears to be incorrect.

Response: It is agreed that EPA Figure 4-3 provides a number of additional data for point of departure and risk-specific doses and that these data were considered by EPA in the weight of evidence. However, Table 4-9, which is a compilation of cancer risk estimates, shows which of those data were used to derive slope factors for TCE. Of those derived, the upper end value of 0.4 mg/kg-day^{-1}, which forms the basis for the EPA risk-based concentration for TCE is based on a drinking water study of ecological design. Thus this study was an oral study. While it is the case that EPA derived additional estimates higher than the 0.4 mg/kg-day^{-1}estimate, in discussing these EPA stated:

> Two sets of estimates appear to lie apart from all others. On the low end, rats appear to be less sensitive than mice or humans. On the high end, estimates from the Anttila study are rather uncertain, based on a small number of cancer cases and an assumed uniform exposure duration of 15 years. Setting aside these lowest and highest estimates, there appears to be convergence of the

> other estimates, even though they are derived from different sources. The remaining slope factors, per mg/kg-d, are 2×10^{-2} (derived from occupational inhalation exposure), 3×10^{-2} to 2×10^{-1} (derived from mice), and 4×10^{-1} (derived from residential drinking water exposure). Because they are supported by diverse studies and do not reflect the highest estimates (from the Anttila study) or the lowest estimates (from the rat studies), these remaining estimates constitute a middle range of risk estimates where confidence is greatest. This middle range is robust in the sense that it is not likely to be dramatically altered by a new study or by minor changes in the analysis of existing studies.
>
> This new slope factor range, 2×10^{-2} to 4×10-1 per mg/kg-d, lies just above EPA's previous slope factor for TCE, 1.1×10^{-2} per mg/kg-d. ….. (EPA 2001 page 4-27).

Thus EPA 2001 placed primary reliance on CSF values between, 2×10^{-2} to 4×10^{-1} mg/kg-day^{-1}, with the CSFs derived based on inhalation data from the Finnish studies (Anttila et al. 1995) set aside. Remaining studies are the derivation of a CSF of 0.02 mg/kg-day^{-1} (EPA 2001 Table 4-9) based on an assumed air concentration equivalent to the TWA in the Henchler et al. (1995) study and the Bois (2000a,b) calibration of data from two gavage studies in mice (NTP 1990 and NCI 1976, [see EPA 2001 Tables 3.1, 4.4, and 4-9, and page 4-19]). Although there is one study in the range based on inhalation exposure (Henchler et al. 1995), this study did not have exposure information and exposure was instead inferred to be the TWA. Remaining studies in the range identified by EPA as the range of primary reliance were all oral studies and, most relevant for this discussion, the upper-end of that range was based on an oral exposure setting.

Regardless, the statement will be removed from the Supplemental FS.

<u>References:</u>

Anttila, A; Pukkala, E; Sallmen, M; et al. (1995) Cancer incidence among Finnish workers exposed to halogenated hydrocarbons. J Environ Occup Med 37:797–806.

Bois, FY. (2000a) Statistical analysis of Fisher et al. PBPK model of trichloroethylene kinetics. Environ Health Perspect 108(suppl 2)275–282.

Bois FY. (2000b) Statistical analysis of Clewell et al. PBPK model of trichloroethylene kinetics. Environ Health Perspect 108(suppl 2)307–316.

U.S. EPA. 2001. Trichloroethylene health risk assessment: Synthesis and characterization. EPA/600/P-01/002A. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

NTP. (1990) Carcinogenesis Studies of Trichloroethylene (Without Epichlorohydrin) (CAS No. 79-01-6) in F344/N Rats and B6C3F1 Mice (Gavage Study). NTP TR 243. Research Triangle Park, NC: U.S. Department of Health and Human Services.

NCI (National Cancer Institute). (1976) Carcinogenesis Bioassay of Trichloroethylene. National Cancer Institute Carcinogenesis Technical Report Series No. 2. HEW Publication No. (NIH) 76–802.

<u>Specific Comment 5: Pages 28 -29, Section 5.3.5 Evaluation of Potential After-Hours Exposure</u>

The Draft FS Report argues that the Site-specific action levels are linear, thus for those people who occupy buildings for a shorter period of time each day, annually, or number of years, the risk is lower. Although this may be true theoretically for some workers, the Draft FS Report does not

sufficiently support its contention that the workers in these buildings work other than during "normally operating building conditions" that these workers are necessarily exposed for less time than workers during those hours.

The Draft FS Report dismisses the impact of vapor intrusion on building occupants who are expected to be in buildings during non-normal business hours when the ventilation systems are off or operating in a mode that could result in elevated indoor air TCE concentrations. The only workers identified in the Draft FS Report are janitors, maintenance staff, and professional staff. It is not clear that there has been any effort to identify other workers who may work full-time jobs in buildings primarily during non-normal business hours such as security personnel who often staff buildings after hours. For the remedy to depend on identifying hours of occupancy, a method to determine when the buildings are occupied must be developed. On the other hand, if the remedy requires that during certain time periods workers cannot use the building due to increased concentrations of TCE and other VOCs in indoor air from the subsurface, institutional controls (ICs) should be developed to prevent such regular occupancy.

<u>Response:</u> Please refer to response to General Comment 10.

<u>Specific Comment 6: Page 31, Section 6.4 Identification of Technologies</u>

Certain conditions have proved to cause increased levels of contamination reaching indoor air through vapor intrusion, such as the existence of conduits or areas where building ventilation does not reach. The existence of such conditions required preliminary interim action, such as sealing of conduits and addressing unventilated spaces, and structures that reach below the groundwater table (basements, elevator shafts, etc). These conditions should be addressed prior to implementation of any ongoing remedy for a particular building.

<u>Response:</u> Section 8.2.2 of the draft Supplemental FS (now Section 9.2.2 of the revised FS) identifies remedial alternatives that may be required under specific conditions as those outlined above. For example, conduit sealing is specified for those conduits that provide a preferential pathway to the subsurface. Similar to the approach previously used at the Site, the Draft Supplemental FS provides for walkthroughs that would identify unique conditions that may result in exceedance of long-term exposure goals.

<u>Specific Comment 7: Page 44, Section 6.5.4.2 Mechanical Ventilation - Cost</u>

The cost subsection only presents the HVAC system retrofit costs. The increased energy costs associated with both increased ventilation during normal hours and continuous ventilation during after-normal business hours occupancy should be included in the Revised FS Report.

<u>Response:</u> Section 6.5.4.2 (now 6.5.5.2 of the revised FS) – "costs" does not provide the costs only for retrofitting an HVAC system. While the purpose of the initial screening is to qualify costs as low, medium or high, this section indicates that the cost for retrofitting an HVAC system is low, but also adds that installation of a new HVAC system is medium to high, depending on the size and use of the building. Chapter 7 and Table 7-3 provide a more detailed evaluation of costs.

Section 7.2.7 (now Section 7.2.8 of the revised FS) refers to an EPA study indicating that increased total energy consumption is less than 5% if the air exchange rate is increased to 1/hr. In addition, as shown in General Comment 10, exposure of after-hour workers does not necessitate operation of HVAC system during after-normal business hours. Therefore, the qualitative costs for mechanical ventilation in Section 6.5.4.2 does not need to change.

<u>Specific Comment 8: Pages 51-53, Section 7.2 Detailed Analysis of Alternatives</u>

The detailed analysis of alternatives reviews seven of the nine NCP criteria for the proposed remedial actions. This analysis does not provide sufficient detail regarding each alternative to support development of a proposed plan.

Overall protection of human health and the environment - EPA has a preference for those remedies that do not expose receptors to contamination. Several remedial alternatives proposed prevent exposure inside the buildings by stopping contamination from entering the buildings through the vapor intrusion pathway. Other alternatives considered allow the VOCs to enter the building but dilute them to levels below EPA's levels of concern. The discussion of this criteria should reflect EPA's general preference for preventing all exposure rather than relying on dilution to prevent higher exposure.

<u>Response:</u> The purpose of ventilation is not to "dilute" VOCs to levels below EPA's levels of concern. Ventilation is essentially a removal action in that indoor air is replaced with outdoor air. Ventilation at an air exchange rate of 1/hr has been shown at the site to be effective in reducing concentrations to below long-term exposure goals.

Implementability*:* When reviewing the proposed alternatives, the Draft FS Report does not adequately analyze the ability of the remedial alternatives to achieve the remedial action goals on an ongoing basis. Certain of the remedial alternatives follow a more common pattern of implementation: installation of a remedial system, ongoing operations and maintenance (O&M) by the potentially responsible parties (PRPs), and monitoring. The use of ventilation systems, on the other hand, uses equipment that is already in place for another purpose and relies on operation by the building managers for implementation and O&M. Although physical installation of the ventilation systems may be simpler than installing new equipment because the ventilation equipment is generally in place already, the administrative operation of the systems is far more complex to implement. Additionally, over the period that the systems will have to operate, there will be new tenants, new building owners, and new construction. In order to adequately assess this criterion, these issues must be identified and addressed in the report.

<u>Response:</u> Mechanical ventilation is one of the remedies recommended in vapor intrusion guidance (e.g., ITRC 2007[1]; DTSC 2005[2]), and has been implemented at several sites in California and elsewhere. Whereas responsible parties at these sites may monitor the operation of HVAC systems and their effectiveness in meeting long-term exposure goals in indoor air, it has been both practical and realistic for the building owners/occupants to retain the primary responsibility to operate, service, and maintain the HVAC systems.

Consequently, EPA's observation in the comment above is correct in that it is expected that the building owner/occupant would be operating the system. It is important to implement a remedy that minimizes disturbances to building operations. MEW Companies do not own the properties in the MEW Area. Several of the properties are occupied by companies with very restrictive security measures to ensure proprietary, product, and security controls. In addition, various operations in the buildings (e.g., computer labs, offices, kitchens) may require different operation modes of HVAC systems. Therefore,

[1] ITRC, 2007, "Technical and Regulatory Guidance Vapor Intrusion Pathway: A Practical Guide", January
[2] DTSC, 2005, "Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air", Revised February 2005

the HVAC system needs to be operated by the occupant, who is most knowledgeable of operational requirements.

In addition, following on the information in the paragraph above, it is more likely that owners/occupants would provide access to monitor and inspect a remedy that is already in place (such as operations of an HVAC system), rather than provide access for a more intrusive remedy that would require trenching and piping on the property and in many cases inside the building enclosure. Consequently, mechanical ventilation may in many cases be the only feasible and implementable alternative.

In addition to remedial technologies, the Draft Supplemental FS has been revised to propose several ICs to ensure proper implementation of remedies, including mechanical ventilation, while minimizing disturbances to operations. More information on institutional controls (including administrative operations) can be found in Chapter 8 of the revised FS.

Specific Comment 9: Pages 64-68, Section 7.2.7 Mechanical Ventilation

Although the assertion that mechanical ventilation has been used in the past to improve indoor air quality is true, historically this method has been used to remediate indoor sources of contaminants and to prevent entry of contaminants from the outdoor air. For instance, in the 1991 EPA Indoor Air Quality guidance cited, there is discussion of contamination from outdoor air, but no mention of use of HVAC to address contamination coming from the subsurface. Use of mechanical ventilation to prevent or to reduce the impact of intrusion of subsurface contaminants is relatively new and presents unique concerns and potential costs that are not identified in the report.

Effectiveness: The Draft FS Report asserts that an air exchange rate of 1 per hour has been shown to be appropriate screening tool for determining whether vapor intrusion may occur. EPA has not yet agreed that data collected to date is sufficient to show that this is the case or that such air exchange levels are necessarily appropriate to achieve the remedial goals if lower air exchange rates achieve the same result. Even if an air exchange rate of 1 per hour is sufficient to keep the indoor air contaminant levels below levels of concern, it remains to be determined when and how this rate is achieved and how it will be measured, monitored, and enforced. Additionally, there is no discussion of how to ensure that the air exchange of 1 per hour is achieved throughout the building (e.g., system balancing). Reduction in TCE/VOC levels should also be included in evaluation.

Response: Please refer to response to General Comment 9. Data collected to date supports using 1/hr air exchange rate as a screening level for proper ventilation. As mentioned in the response to General Comments 6 and 8, the Draft Supplemental FS is revised to include provisions for a monitoring plan. The costs presented in Table 7-3 present a range for monitoring depending on whether or not service measurements can be obtained from occupants (such as for state-of-the-art automated system) or measurements of air exchange rates have to be obtained independently. Section 8.4.3 of the Draft Supplemental FS (now Section 9.4 of the revised FS) will be revised to include measurements of air exchange rates as one way of monitoring for proper ventilation.

Regarding the last sentence in the comment above, the RI presents analyses of the effect of ventilation on concentrations (for example when for the same building the ventilation system is on or off). The RI and Section 2.2.6 of the Draft Supplemental FS indicate that for those buildings when ventilation was on and off, there is at least a 10-fold reduction in TCE indoor air concentrations when the ventilation system is on. Section 7.2.7 (now Section 7.2.8 of the revised FS) will be revised to include this information.

Long Term Effectiveness and Permanence: The Draft FS Report states that "[p]ermanence can be demonstrated through inspections and maintenance of ventilation systems, which is a routine function typically performed by building owners and occupants." Although building owners and occupants may inspect and maintain HVAC systems, the Draft FS Report must discuss how to ensure that this requirement will be achieved and monitored. It is expected that there will be an ongoing relationship with each building manager and reimbursement for use of building equipment to maintain adequate air exchange rates. Positive pressure ventilation should also be included in evaluation.

In the discussion of Soil Vapor Extraction in Section 7.2.14, the Draft FS Report explains that "if the system is shut down, VOCs may volatilize from the groundwater, through pores in the unsaturated soils, and potentially into the building." Similarly, where a ventilation system is being used for the vapor intrusion remedy, when the system is shut down or operating in "low" mode, VOCs entering the building through the vapor intrusion pathway may be potentially indoor air concentrations at levels of concern. Explain how the ventilation remedy will prevent such shut downs from occurring. The Draft FS Report refers to the use of management controls to ensure the operation of the systems. The form and content of these management controls must be discussed.

Response: Regarding the first paragraph, please refer to the response to the earlier part of this comment. In addition, the revised Supplemental FS includes a chapter on institutional controls that address relationships between building owners and PRPs. Section 8.4.3 of the Draft Supplemental FS (now Section 9.4 of the revised FS) will be revised to include positive pressure as one type of measurement for ventilation systems, although, it is not the only indication for proper ventilation.

Regarding the second paragraph, the comparison of shutting down a ventilation system to shutting down an SVE system is not accurate. The discussion of shutting down an SVE system in Section 7.2.14 (now Section 7.2.15 in the revised FS) is in the Long-Term Effectiveness Section. Shutting down the SVE system for the long-term is not similar to a temporary shut down a ventilation system for maintenance or in after-normal occupancy. The first may result, in the absence of other remedial measures, in volatilization into building enclosures. The second has been shown to be protective of human health (see for example response to General Comment 10).

Implementability: The Draft FS Report asserts that the use of mechanical ventilation as a remedy for vapor intrusion is relatively easily implementable. Use of mechanical ventilation as proposed in this alternative is attractive because it uses equipment that is standard in many commercial buildings. However, implementation of the remedial option may be very complex and must be discussed in more detail. Each of the systems may be slightly different, and the control over the systems will vary widely among the buildings. The FS must discuss how use of ventilation systems will actually be implemented, monitored, and enforced.

Response: Please see response to the first portion of this comment above.

Cost: The Draft FS Report fails to provide a cost breakdown for additional electrical costs to run the HVAC systems to meet the remedial goals. The Draft FS points to a statement in EPA's 1991 guidance that use of ventilation to address indoor air contamination may not increase operational costs more than 5% annually. However, the true costs of running these systems must be calculated in order to evaluate this alternative. EPA has calculated a cost estimate for increased energy costs based on a hypothetical building operating at an air exchange of 0.5. This hypothetical situation (attached hereto as HVAC Optimization – Incremental Ventilation Costs) calculates an increased

energy cost of $9,375 annually. These amounts must be estimated for the buildings in which the FS proposes to use ventilation as a remedy.

Response: The evaluation of long-term or on-going (utility) cost impact of the ventilation measures can be quite involved. However, the minimal amount of outside air typically required to properly ventilate a space is typically not a large portion of the overall load on a given (small, comfort-cooling) packaged AC unit. Additionally, the overall operational cost are typically evaluated over a year-long period, as the net-effect of outside air being brought into a packaged air conditioning unit will change throughout the year. During mild weather (65-78 degrees), the net effect will be beneficial, or at the least, zero added load to a given packaged AC system. During design extremes (peak summer and winter months), there is still some potential for off-setting of added load from outside air as some units (even during cold winter months) serving interior spaces are required to provide cooling.

During implementation of the remedy, if the need to determine accurate costs arises, then these costs can be calculated.

Specific Comment 10: Pages 65-66, Section 7.2.7 Mechanical Ventilation

The Draft FS Report states that "using positive pressure as the indication for proper ventilation can be problematic for many reasons". EPA disagrees with the assertions provided in the Draft FS Report about the "problematic use" of positive pressure ventilation as an appropriate remedial alternative to address the VI pathway at the Site.

- **Page 66, first bullet. The Draft FS Report refers to a building likely having both positive and negative pressure areas, which is possible. This is why, striving to maintain positive pressure in a building would result in most areas having positive pressure vs. the opposite.**

Response: There is no one-size-fits-all regarding building construction, use, or operation that would allow positive pressurization in most areas of a building. Moreover, if a structure is not originally designed to maintain a positive pressure therein, attempting to induce a positive pressure in the structure will more often than not require significant modifications to the structure, the structure's envelope, mechanical systems that support the structure, and functional uses of the structure. In a building not designed to accommodate pressurization air will be rapidly flowing out of the building envelope, via leakage pathways.

- **Page 66, second bullet. The Draft FS Report refers to pressure differentials that could vary with weather and ventilation operation. This statement appears to describe a building with passive ventilation, not active mechanical ventilation. This does not appear to be a concern.**

Response: While this is true of buildings that are passively ventilated, it is also true of mechanically ventilated buildings that are constructed with wall and ceiling assemblies that are not airtight, wall assemblies that have large openings (e.g., roll-up doors), and buildings that have limited mechanical systems (e.g., warehouse and storage facilities). Thus weather affects and ventilation operation are very relevant to buildings that are mechanically operated as well as those that are passively ventilated.

- **Page 66, third bullet. The Draft FS Report refers to a temperature differential between the inside of the building and the outside and how this affects pressure differential inside the building during the heating season making air flow into the buildings at lower elevations and flow out of the building at higher elevations. Such situations typically do not occur in relatively air-tight buildings. Also, it is not typical for this situation to occur in buildings**

which might leak some air out. This statement may apply to a building with passive ventilation.

Response: The stack effect affects all buildings, even those that are one story in height; albeit, its effects are less noticed. Temperature affects are greatest in buildings constructed with multiple stories that have tall openings and/or limited zone controls. Accordingly, temperature differentials are significant in most structures, it cannot be ignored, it is a design consideration, and it will negatively affect any attempt at positive pressurization in buildings not initially designed to perform with positive pressurization.

- **Page 66, fourth bullet. The Draft FS Report refers to pressure differentials inside the building being caused by wind. Again, this statement appears to fit better the passive ventilation, but not the mechanical ventilation system. We don't see a concern here.**

Response: Pressure differentials that originate from wind pressures outside the structure, affect buildings with both passive and mechanical ventilation systems. Affects of wind pressure loads upon the building envelope, inducing pressure differentials indoors, has much more to do with the air-tightness of the building envelope, or the resistance to infiltration, than any ventilation system – passive or mechanical. Moreover, openings in the building envelope (e.g., doors ,windows, vents, etc.) that face prevailing winds can have profound effects on pressures therein. Building envelopes that are not airtight have higher indoor pressures on the windward side of the structure and lower, relatively negative, pressures on the leeward side. Moreover, as winds shift direction, so does the pressure loading and the induced internal pressures therein.

- **Page 66, fifth bullet. The Draft FS Report refers to construction and physical building characteristics that would make maintaining positive pressure difficult. The answer here might be ductwork balancing, which would enable each space receiving more supply air and less return air, and, therefore, resulting in positive pressure.**

Response: In order to induce a positive pressure inside a building envelope, relative to outside the envelope, many characteristics of the entire building assembly are involved to be successful, e.g., wall and ceiling systems, openings in those systems, communication between interstitial spaces, leakage pathways, functional use within the building, the size and capacity of the mechanical system, the size of the ductwork, the placement and distribution of supply registers, etc. Ductwork balancing alone is not sufficient to permit pressurization. Ductwork balancing is an effort to provide equal distribution of available conditioned air; within the capacity of the system. If the HVAC system is not capable of delivering sufficient airflow capacity to induce a positive pressure because of excessive exfiltration, ductwork balancing would not be adequate.

Inducing positive pressures within a building assembly may not be possible within the existing system capacity of many buildings. Attempting to induce positive pressures inside an existing building where pressurization was not inherent in the building's original design, use and function is much more complex than ductwork balancing; it involves infiltration studies, sealing leakage pathways, enhancing HVAC system capacity, stopping and/or reducing exhaust systems, changing building use patterns, etc. Moreover, some construction methods of existing buildings may not allow for significant modification that would permit sustained positive pressures, not without significantly altering the building (at a significant cost in construction and cost to operate. For example, it is often not possible to modify buildings with massive wall assemblies without altering structural characteristics, functional elements, and fire code requirements. Buildings with hollow-cavity wall assemblies that are in open communication with non-functional spaces, curtain wall assemblies, plenums, and mechanical systems may not be effectively sealed to allow pressurization.

Simply providing increased ventilation air in the system, but not making sure that positive pressure is being maintained may not effectively achieve adequate reduction of VOCs in the areas with neutral and negative pressure.

Response: The measurement of differential pressure is a simple operation. However, differential pressure measurements must be taken across some form of barrier at two discreet locations. Accordingly, there may be (and most-likely will be) a range of differential pressures within a given building – both positive and negative, depending on where the two discreet locations are positioned within the building. There will also be wide ranges of differential pressures within a building driven by construction and physical building characteristics; high-rise buildings experience temperature gradients that can affect differential pressures (stairwells vs. occupied spaces, upper floors vs. lower floors, etc.), restrooms, kitchen areas and other odor-generating environments are kept at a negative pressure to mitigate odor migration, wind-loads and leakage rates can impact building pressure, etc.

During the RI process, several commercial buildings were sampled. Samples were collected from a number of locations from each building, representing various uses: Offices, lobbies, conference rooms, laboratories, warehouses, kitchens, bathrooms, utility rooms, etc. In addition, many types of buildings were sampled, some of which may be considered as "tight" buildings, and others as "leaky" buildings. It was determined in the process that regardless portion of buildings with typically negative (e.g., bathrooms, kitchens) or neutral (warehouses, leaky buildings) pressure showed concentrations below the long-term exposure goals as long as the air exchange rate was 1/hr. The only exception noted was NASA building 210 in which the entire HVAC system was ducted in a way that it created a negative pressure zone under the raised foundation inducing volatilization from the subsurface into the air under the floor. Because the HVAC system was designed to push the air from that zone into the enclosed space, some TCE concentrations were found indoors at levels higher than the long-term exposure goal. NASA re-ducted the HVAC system to supply air from the ceiling rather than through the raised floor, and the TCE concentrations dropped to below the long-term exposure goals.

In short, differential pressure measurement within and throughout a building may prove to be a useful component of evaluating building ventilation, but it should not be used as the only validation measurements, and must be combined with other collected pieces of data in order to fully quantify ventilation of a given building or space (i.e.: total outside air into a building and total exhaust out of a building). Accordingly, Section 8.4.3 of the Draft Supplemental FS (now Section 9.4 of the revised FS) will be revised to include pressure differential as a measurement tool. The monitoring plan will provide additional details as to the advantages and limitations of this measurement, and how pressure differential measurements can be used in combination with other measurements to monitor the effectiveness of the remedy.

Specific Comment 11: Page 68, Section 7.2.7 Mechanical Ventilation - Cost

The Draft FS Report states that the electrical costs associated with the increased ventilation are not significant, and therefore, they were not included in the annual O&M costs. This finding does not appear to be substantiated, especially as the annual operational expenses should also include increased cooling and heating costs to match the increased ventilation supply. Continuous ventilation, which is required for the after-hours workers, and associated costs need to be presented in the Revised FS Report.

Response: Please refer to responses to General Comment 10 and Specific Comments 5 and 9.

Specific Comment 12: Page 83, Section 7.3.3 Long-term Effectiveness and Permanence

The Draft FS Report proposes that the "inadequate operation of ventilation systems", which is when air exchange is less than 1/hr, "should be reported to tenants, owners, and EPA". It is important to note here that building owners/operators are under no obligation to maintain air exchange of 1/hr or greater. Instead they are only responsible to provide fresh air to the occupants based on actual physical count of the people in the buildings at each given time. Moreover, they are encouraged by Title 24 and other energy conservation initiatives to keep energy costs, including ventilation/cooling/heating costs down. There is currently a technology (demand-control ventilation), that is designed to accomplish exactly that. As a result, the building managers who use such technology may not provide air exchange of 1/hr even during the normal working hours.

Response: The Draft Supplemental FS has been revised to include institutional controls that would address the comment above (please refer to responses to EPA comments on revised IC section). Realizing that this remedy would be operated by the building occupant, the remedy would include additional monitoring of the system by the PRPs to ensure that it is operating per the specifications of the Draft Supplemental FS, and to collect indoor air samples when necessary. The Draft Supplemental FS will be revised accordingly.

Specific Comment 13: Page 89, Section 8.2 Selection of Remedial Alternatives

This section does not adequately explain how the appropriate remedial alternative would be selected for each individual building. Insufficient information may impact EPA's ability to develop a Proposed Plan for the Site.

The Draft Supplemental FS Report should be revised to provide comprehensive details for the implementation of recommended alternatives at specific buildings, which may impact EPA's ability to develop a Proposed Plan for the site.

Response: Section 8.2 (now Section 9.2 of the revised FS) has been revised to include additional information that will be helpful to EPA in preparing the proposed plan.

Specific Comment 14: Page 90, Section 8.2.2 Specific Required Alternatives

Conduit sealing is only proposed if conduits are in direct contact with groundwater. However, conduit sealing is intended to reduce vapor intrusion (not groundwater intrusion), which could occur at source sites and over the groundwater contaminant plume. The statement should be revised to include all conduits that may serve as a preferential pathway for vapor intrusion irrespective of the source (groundwater or soils).

Response: Section 8.2.2 (now Section 9.2.2 of the revised FS) of the Draft Supplemental FS has been revised accordingly.

Specific Comment 15: Table 8-2 Proposed Institutional Controls

Under enforcement controls, the authors provide the following discussion: "*Annual verification that active remedial option selected is operating. Less frequent post-construction verification if a passive remedy is implemented*." While this may be true for non-impacted areas, it will be necessary to demonstrate (with more TCE testing not less) that a passive system is sufficient to address vapor intrusion in those areas of the plume where vapor intrusion is occurring. Historically, the radon program has recommended active systems over passive systems because they are more effective at mitigating this exposure pathway.

Response: Please refer to response to General Comment 12. The section on institutional controls has been revised.

NOTE: ***The following comments on Section 8.3 Institutional Controls have been previously provided to the MEW Companies and Section 8.3 has subsequently been revised. See also Attachment 3: EPA Comments on the Revised Institutional Controls Section***

Response: Regarding the comments below, please refer to responses to comments on the revised Institutional Controls Section, and the revised Institutional Control Section. The revised FS includes a new Chapter 8 on Institutional Controls.

Section 8.3 Institutional Controls

1. ICs Discussion Is Too Vague.

The discussion of potential institutional controls (ICs) in the Draft Supplemental Report for Vapor Intrusion at the MEW Site (Draft FS Report) is too vague to allow for a complete evaluation of the ICs for the remedy. Particular with a remedy that may rely heavily on ICs for remedy implementation, the ICs must be detailed sufficiently in the FS to allow for a full and fair comparison of alternatives. The discussion must be thorough enough to develop an institutional control implementation plan including responsibilities for the full life-cycle of each IC.

2. General Discussion of ICs Categories.

The Draft FS Report briefly raises a few IC options in the most general terms, listing the general categories of available ICs. These are good representative categories of ICs, but insufficient details are provided to determine how and when the ICs would be implemented. Additionally, the purpose of the ICs discussed appears to only be assurances of access for maintenance and annual verification of the engineered remedy rather than as a component of the remedy itself. Also, while the Draft FS Report includes a proposal to have the City of Mountain View (City) provide informational material to homeowners and developers by the City, it does not include the purpose and content of this material.

3. Evaluation of ICs for Each Remedial Alternative.

The Draft FS Report evaluates several remedial alternatives. For each of those alternatives, specially tailored ICs may be necessary. The FS should go through which ICs would be applicable for which alternative, each of the ICs strengths and weaknesses, and whether they would be used in combination with other ICs. Then, discussion of each individual IC in the Revised FS Report must provide, at a minimum:

- the relationship of the proposed ICs to each of the engineering controls/alternative(s);
- objectives of the ICs;
- performance standards;
- type of control envisioned;
- cost of implementation;
- IC monitoring and implementation plan;
- modification and termination processes; and
- enforcement plan

4. Range of ICs - Minimal to Complex.

Certain remedial alternatives proposed would require minimal ICs. For instance, following installation of a sub-slab ventilation system, ICs may be required to ensure that there is no one tampers with the sub-slab ventilation system, to inform building workers of what activities could interfere with the system, and to provide access for ongoing maintenance and operation activities. Also, ICs may be used to inform future developers of construction requirements as a part of the remedy.

On the other hand, the use of building ventilation systems to keep levels of volatile compounds (VOCs) entering from the subsurface into the building low requires a much more intensive use of ICs. This alternative requires gaining the cooperation of operators of existing equipment as the engineered remedy. The equipment itself varies from building to building, and the operation may be controlled by a variety of entities, including the building owner, the tenant, or a management company. This is an example of where the scope of administrative and legal activities involved would be much broader. The ICs must ensure that those who run the heating, ventilation, and air conditioning (HVAC) systems are informed of the steps to be taken to meet the remedial requirements, ensuring that these steps are taken, and that there are enforcement mechanisms in place where there is failure to cooperate would be the ICs for this remedy. Also, the ICs will have to include informational mechanisms to notify the appropriate entities when building management, tenancy, or configuration change.

5. Layering.

Certain ICs can stand alone, while others are most effective when layered or used in a series, using more than one method to maintain the remedy's effectiveness. Layering is particularly important where some ICs cannot be immediately implemented, such as when an IC considered relies on enactment of a local ordinance, as is suggested in the Draft FS Report. Also, layering might be appropriate where one IC is necessary to ensure the implementation of another, such as where a contractor is used to provide updates on building ownership and tenancy in order to ensure that new owners and occupants are provided the appropriate information.

6. Full evaluation of NCP criteria.

Because ICs are part of the remedy itself, each IC must be compared using the National Contingency Plan's (NCP) nine criteria. CERCLA 121(d)(2)(B)(ii)(III). Just as with the remedial alternatives, discussion of the ICs proposed must include, among the other criteria, any applicable or relevant and appropriate requirements (ARARs) concerned with ICs, the ICs' short-term and long-term effectiveness, and their implementability. Importantly, the discussion of implementability should discuss how likely it is that the IC can be achieved. Also, it is important to make clear what entities will ultimately maintain responsibility for the necessary activities through each phase of the IC.

7. Actual implementation.

EPA appreciates that the MEW Companies have started the dialogue with the City of Mountain View to discuss the available options to use current City regulations and possibly implement new ordinances or zoning overlays to accomplish some of the ICs. The Revised FS Report should identify specifically what steps the remedy would encourage the City to take and what would potentially be involved with IC implementation.

8. Costs.

In the discussion of the nine criteria, the Revised FS Report must provide a cost analysis for each IC. The cost analysis must consider ongoing costs for IC implementation. This would include costs incurred by any entity, including EPA, the PRPs, the building owners and tenants, and the City.

9. Monitoring.

The FS Report should distinguish between monitoring of engineered remedy and ICs as part of the remedy itself. The Draft FS Report discusses the methods of monitoring the implementation of the engineering controls rather than what the ICs themselves would be. Monitoring of the remedy is part of the operations and maintenance (O&M) of the remedy. ICs provide the informational and enforcement mechanisms. Thus, for instance, it may be required to have regular inspections of the HVAC systems being used to ensure that they are working properly. This would be an O&M function. Where mechanisms are necessary to ensure that the HVAC is actually operated when necessary, that would be an IC function. Additionally, the ICs may include a monitoring function to inform those implementing the remedy of any administrative change that might impact the remedy, such as a change in building ownership, management, and occupancy.

10. Enforcement and Implementation.

The Draft FS Report confuses EPA's enforcement authority with the requirement for enforceability of the ICs by the entities implementing the remedy. For all parts of this remedy, EPA will maintain its access and enforcement rights. However, EPA expects the PRPs to implement the remedy and to indicate how they intend to enforce implementation to ensure that the selected remedial action is feasible. Particularly if the remedy selected requires participation by many entities, the PRPs must explain how they intend to achieve participation on an ongoing basis. This information is not discussed in the Draft FS Report. In fact, the PRPs point to three reasons that proprietary controls are not likely to be effective. However, these same reasons could be cited for why a remedy reliant on the participation of so many entities is not feasible.

APPENDIX B

RESPONSES TO EPA COMMENTS ON REVISED INSTITUTIONAL CONTROLS SECTION

APPENDIX B

Responses to EPA Comments on Revised Institutional Controls Section Middlefield-Ellis-Whisman Study Area, Mountain View and Moffett Field, California

EPA General Comments

General Comment 1. ICs to Require Use of Building Ventilation Systems

Many of the ICs proposed in this Section enlist active participation on the part of non-potentially responsible parties (PRPs) in implementing the VI remedy. Specifically, to implement the remedy alternatives that utilize building heating, ventilation and air conditioning (HVAC) systems to prevent unhealthful levels of volatile organic compounds (VOCs) from the subsurface from accumulating in indoor air, ICs are recommended to require (1) proper use or installation of standard building ventilations systems that will also serve as remedial equipment, and (2) the ongoing operation of those systems as necessary to serve remedial needs.

ICs are not usually the mechanism used for installation and operation of site remedies. Ordinarily in a CERCLA cleanup, PRPs are required to implement and monitor a remedy pursuant to EPA's enforcement authority. PRPs implement the remedy, often utilizing contractors whose activities are assured through their contracts; EPA does not play a role in those contracts other than to require the PRPs to ensure that the contracts fulfill the requirements of the site ROD. With the proposed use of HVAC systems as part of the VI remedy, however, each building operator is essentially being used as a contractor for remedy implementation, and the ICs are the mechanism proposed to ensure that those building operators run the systems in accordance with the ROD requirements. This is not a usual configuration of remedial implementation. Because ICs are being proposed as a method to ensure the remedy implementation, more detail is needed to understand whether and how these proposed ICs will work.

Response: Mechanical ventilation is one of the remedies recommended in vapor intrusion guidance (e.g., ITRC 2007[1]), and has been implemented at several sites in California and elsewhere. Whereas responsible parties at these sites may monitor the operation of HVAC systems and their effectiveness in meeting long-term exposure goals in indoor air, it has been both practical and realistic for the building owners/occupants to retain the primary responsibility to operate, service, and maintain the HVAC systems.

Consequently, EPA's observation in the comment above is correct in that it is expected that the building owner/occupant would be operating the system. It is important to implement a remedy that minimizes disturbances to building operations. MEW Companies do not own the properties in the MEW Area.

[1] ITRC, 2007, "Technical and Regulatory Guidance Vapor Intrusion Pathway: A Practical Guide", January

Several of the properties are occupied by companies with very restrictive security measures to ensure proprietary, product, and security controls. In addition, various operations in the buildings (e.g., computer labs, offices, kitchens) may require different operation modes of HVAC systems. Therefore, the HVAC system needs to be operated by the occupant, who is best knowledgeable of operational requirements.

In addition, following on the information in the paragraph above, it is more likely that owners/occupants would provide access to monitor and inspect a remedy that is already in place (such as operations of an HVAC system), rather than provide access for a more intrusive remedy that would require trenching and piping on the property and in many cases inside the building enclosure. Consequently, mechanical ventilation may in many cases be the only feasible and implementable alternative for existing buildings.

The FS provides a contingency process for operation of HVAC systems (Chapter 9). In summary, HVAC systems would be inspected and the air exchange rate determined. If the air exchange rate is greater than 1/hr, the HVAC system provides adequate makeup air to achieve long-term exposure goals. If the air exchange rate is less than 1/hr, then additional evaluation is warranted: 1) collect indoor air samples to verify that the air exchange rate achieves long-term exposure goals, or 2) modify the HVAC system to increase the air exchange rate to at least 1/hr, or 3) select and implement an alternative remedy from the list provided in the FS.

In addition to remedial technologies, the MEW Companies have proposed several ICs to ensure proper implementation of remedies, including mechanical ventilation, while minimizing disturbances to operations. More information can be found in the responses to EPA requests for details in the specific comments below.

General Comment 2. Restrictive Covenants

Comprehensive evaluation of the use of restrictive covenants as part of the VI remedy is necessary to fully evaluate how effective other IC alternatives will be at meeting the remedial objectives. As discussed in the introductory language about proprietary controls, the most common IC used for CERCLA remedies is the recording of restrictive covenants. Restrictive covenants act to inform owners, and through them the occupants, of property conditions and use restrictions due to potential exposure to contamination and to avoid interference with operation of a site remedy. Restrictive covenants provide the certainty of running with the land, as well as direct enforceability by EPA, and sometimes the State, for failure to comply with the covenant. There are several significant ways in which the ICs necessary for this remedy differ from traditional ICs, thus restrictive covenants may not be appropriate for this remedy. However, the revised ICs section should address why this is the case and how the characteristics of restrictive covenants, such as notice and certainty, will be met by use of other ICs.

Response: We agree with EPA's statement that there are "several significant ways in which the ICs necessary for this remedy differ from traditional ICs, thus restrictive covenants may not be appropriate for this remedy". However, there are different ICs already in place or that can be obtained that will provide adequate notice and certainty similar to those derived from restrictive covenants.

A new subsection 8.4.3 Notice and Certainty has been added to Chapter 8 in the revised FS to describe how the proposed ICs provide adequate notice and certainty.

<u>**General Comment 3: Compliance with Applicable or Relevant and Appropriate (ARARs)**</u>

This comment applies to the ARARs analysis throughout this Section. Unless there is a specific regulation that an IC would or would not comply with, the conclusion should be that there are no ARARs that the IC would be concerned with. Additionally, although substantive permit requirements can be ARARs, the administrative imposition of requirements through a permit cannot be ARARs.

<u>Response:</u> Comment noted. The chapter will be revised accordingly.

EPA Specific Comments

<u>Specific Comment 1. Section 9.1.1 Objective</u>

The Summary of Objectives should more fully explain how the proposed VI ICs may differ from the more commonly used ICs. Specifically, where many ICs fulfill the remedial objective of notice, here there are ICs proposed to actually require building operators to perform part of what is the site remedy.

<u>Response:</u> The following paragraph will be added to Section 9.1.1 (now 8.1.1 in the revised FS):

ICs proposed for the vapor intrusion remedy may differ from traditional ICs. For example, one of the remedies, mechanical ventilation, is expected to be operated by the property owner/occupant not by the PRPs, although the PRPs will monitor its effectiveness in meeting long-term cleanup goals. However, as explained in Section 8.4.3, several scenarios are developed demonstrating that adequate notice and certainty can be achieved by the proposed ICs.

<u>Specific Comment 2. Section 9.3.1 Zoning</u>

This section explains that zoning as it is currently in the Site area is protective of human health and the environment; however, changes in zoning would not necessarily mean that the remedy would no longer continue to be protective but rather that the remedy as applied to that area may also change. Because there are various land uses throughout the Site, the VI remedy as applied for any individual property may be different. The ICs related to zoning should ensure that any changes in zoning account for the VI remedy and its requirements.

<u>Response.</u> We agree with EPA's statement above that "changes in zoning would not necessarily mean that the remedy would no longer continue to be protective, but rather that the remedy as applied to that area may also change." In fact, EPA's comment above is addressed in the Long-Term Effectiveness and Permanence portion of Section 9.3.1 (now 8.3.1 in the revised FS), which explain that the FS provides protective remedial alternatives that would account for zoning changes. Section 9.3.1 Overall Protection of Human Health and the Environment (now 8.3.1) will be revised to further emphasize this point.

Zoning can be used as a tool to inform owners of requirements within a certain area. Use of a zoning overlay for the Site area is rejected in section 9.3 due to the City's reluctance to use such a tool; however, it should be considered as one of the possible methods to inform developers of limitations within the Site area due to vapor intrusion.

<u>Response:</u> This is addressed in more details in the response to EPA's Specific Comment 4.

<u>Specific Comment 3. Section 9.3.2 Local Government Controls: Local Permits/State Codes. Discretionary Land Use Permit Review and CEQA Review</u>

This section explains that, following selection of a VI remedy in a ROD, the City of Mountain View (City) will consider the remedial action alternatives during California Environmental Quality Act (CEQA) review. The CEQA process could be very helpful in both identifying projects that will

potentially require vapor intrusion mitigation and ensuring that development accounts for Site VI conditions. The section needs to be expanded, however, to explain how the CEQA process will ensure that these requirements are met. It is not clear that this process is applicable to all development at the Site. For instance, there are currently single family residences overlying the groundwater contamination plume and the City has indicated that it may change the zoning of other areas over the plume to accommodate residential property; however, single family residential construction does not undergo CEQA review. This section should explain whether and how the use of the City's discretionary land use permit process would apply to residential development.

Second, this section should describe the process by which the ROD is incorporated into the City's CEQA review process and how requirements in a CEQA review become enforceable. It should be explained how the CEQA review translates into permit requirements; whether requirements raised in a CEQA review can be ongoing; and how the City ensures that the requirements set forth in those permits are met.

Third, this section references the City's mapping and database tools for use as ICs. In the November 22, 2006 letter from the City, the City indicated that these tools are already used by the City to provide ICs for environmental sites. A more detailed description of what tools the City has, how the tools serve the purposes required to implement the ROD, and what additional tools may be necessary to ensure IC effectiveness should be included. Although the City staff is currently well aware of VI issues, staff expertise necessarily will change over time, and there should be systems in place to flag the ICs for both current and future City staff members.

<u>Response:</u> The MEW Companies arranged for meetings with the City of Mountain View to obtain the information requested by EPA in this comment. Chapter 8 will be revised per the information received from the City.

<u>Overall Protection of Human Health and the Environment</u>. Although this section references current code requirements as providing adequate ventilation, it is not clear that the codes require anything beyond the installation of systems capable of operating at such a level. It is not clear that there are any code requirements that require operation of the systems at the level that accomplishes the remedy, or, if there are such requirements, that they are routinely enforced. These issues should be addressed in this section.

<u>Response:</u> The text includes an explanation under Long-Term Effectiveness and Permanence that the City of Mountain View does not implement on-going HVAC system monitoring and enforcement programs. It adds that "other than the inspections that EPA, the Companies, and NASA have already performed on HVAC systems, the City and other government agencies do not regularly enforce or monitor buildings or HVAC system permits and codes." This same section then elaborates that "OSHA (or the City) only becomes involved with HVAC monitoring or enforcement to ensure that reported violations are corrected." For this reason, the MEW Companies proposed that to "ensure long-term effectiveness and permanence of this IC, it should be layered with others". Also, the MEW Companies have proposed in the FS a monitoring plan to verify that the remedy performs properly.

In response to EPA's comment, similar language will be added to the section on Overall Protection of Human Health and the Environment.

<u>Implementability</u>. Although the City has indicated that it has limited resources to implement the ICs for this remedy, there will be coordination required with the City's current practices. This coordination should be addressed in this section.

<u>Response:</u> The MEW Companies met with the City of Mountain View on two occasions in January to explore IC options and to obtain information on the CEQA process and the City's permitting tools and databases. Future meetings with the City, EPA, and MEW Companies will be planned to continue discussions of IC options.

<u>Specific Comment 4. Section 9.3.3 Zoning Overlays or Public Health and Safety Ordinances</u>

EPA understands from the City's letter of November 22, 2006 that there are administrative hurdles to implementation of Site requirements through a zoning overlay or enactment of local ordinances. EPA encourages continued discussion with the City about overlays and ordinances along with other available tools for ensuring that developers and others are informed regarding the risks involved with vapor intrusion a the Site and the VI remedy prior to development.

Additionally, this section assumes that that zoning overlays and ordinances could require ongoing operation of HVAC systems to maintain adequate air exchange and ventilation. It is EPA's understanding that the City's current planning programs do not conduct such ongoing monitoring. EPA acknowledges that the City's resources may not be sufficient to conduct ongoing monitoring that would be required by this remedy, however separate funding for such monitoring should be discussed.

The City suggests in its letter that database tools and mapping tools could serve the same purpose as an overlay zone. As discussed above, more information is needed to explain how those tools currently function and could function in the future. Although staff expertise will be important regardless of the methods used to disseminate the necessary information, staff expertise necessarily changes over time, and this remedy will require education of both current and future staff members.

<u>Response:</u> Section 9.3.3 (now 8.3.3 in the revised FS) does explain that despite the complications presented by the City in their letter, City staff indicated that, if necessary, they would be open to continuing discussions of this IC concept with the Companies and EPA. Before publishing the draft Supplemental FS, EPA and the Companies met with the City to discuss ICs, but given the short time to publish the draft FS, not much could be resolved by the time the FS was submitted. EPA and the Companies will continue discussions with the City on this matter.

As between the zoning overlay and public health and safety ordinance, the City has indicated that a health and safety ordinance premised on the abatement of an existing nuisance may be a better tool to address the HVAC system in existing buildings than a zoning overlay (which appears ill-suited to address the operation of existing HVAC systems). Nonetheless, the City of Mountain View staff has indicated that such controls could require significant staff time to develop, implement, and oversee, and would require City Council policy direction and so could potentially have an impact on the City well beyond its current policies, practices, and resources. The City staff is exploring the health and safety ordinance approach to see if it is technically feasible, but is also concerned that it does not have the resources or staff to implement this kind of ongoing monitoring and enforcement program. Such controls would constitute new un-funded programs requiring legislative authority and enforcement power, resources and fees. As a result, the City staff has indicated that while it will examine internally the feasibility of such an approach, it would be inappropriate at this juncture to rely on such controls (meeting with City of Mountain View staff, January 2008).

As mentioned in the response to Specific Comment 3, information regarding database and mapping tools was obtained from the City and will be included in Chapter 8 of the revised FS.

<u>Overall Protection of Human Health and the Environment.</u> These controls should be evaluated considering that the overlays and ordinances may require installation of appropriate equipment but would likely not include requirements for ongoing operation.

<u>Response:</u> The text includes an explanation in Section 9.3.2 (now 8.3.2 in the revised FS) that the City of Mountain View does not implement on-going HVAC system monitoring and enforcement programs. Accordingly, the MEW Companies have proposed in the FS a monitoring plan to verify that the remedy performs properly. The text in Section 9.3.3 Overall Protection of Human Health and the Environment (now Section 8.3.3) will be revised accordingly.

<u>Long-Term Effectiveness and Permanence.</u> Because State codes and City ordinances can be changed over time, they are not permanent. This section should address how those changes may affect a remedy that relies on State codes and City ordinances as ICs.

<u>Response:</u> State codes and City ordinances may change over time. This applies to any remedy regardless of the media (air, soil, groundwater) because building codes apply to any remedy that is constructed.

Specifically for vapor intrusion, state codes and City ordinances apply as to how a vapor barrier and basements are constructed, how an HVAC system is to be designed and installed, and how raised foundations are to be completed, to site a few examples. In the unlikely event that there is reason to believe that changes in state codes and City ordinance may affect the integrity of the remedy (e.g., lower air exchange rates), the FS provides a procedure for demonstrating the effectiveness of the remedy under the new state codes and/or City ordinance (e.g., confirmation sampling), and also provides a menu item for selection of alternative remedies if needed. If the existing remedy is not effective, then other remedies would be evaluated and implemented when necessary.

The text in Section 9.3.3 "Long-Term Effectiveness and Permanence" (now 8.3.3 in the revised FS) will be revised to reflect the language above.

<u>Implementability.</u> Although the City discussed the issues with enacting an overlay zone or passing new ordinances in its November 2006 letter, the City did not state that these were not implementable entirely and made clear its availability for further discussion of these ICs. EPA encourages continued dialogue between the MEW Companies and the City regarding the implementability of these ICs.

<u>Response:</u> The MEW Companies and EPA are continuing discussions with the City of Mountain View regarding the implementability of overlay zones.

<u>Cost.</u> This section should address both the cost of ordinance development and implementation. The costs involved with ongoing inspection and monitoring of the systems in place for remedial purposes are part of Site O&M and should not be assumed to be absorbed by the City. Costs to conduct the inspection and monitoring should be considered when costing out the O&M of the VI

remedy, and costs to implement this through inspections pursuant to City ordinance or zoning should be evaluated as part of this section, regardless of the source of the funding.

Response: Because ordinances are not developed or placed by the MEW Companies, we do not have cost information on developing and implementing ordinances.

Specific Comment 5. 9.3.4 Proprietary Controls: Covenants

This section states that covenants are "binding on subsequent owners if notice is given to the subsequent owner and if there is a clear statement in the agreement to bind future owners. Recording covenants would ensure enforceability . . . ." Recorded environmental covenants in California can run with the land and be enforceable on future owners. This section should clarify whether agreements between private individuals that do not run with the land and are not recorded can be binding on third parties.

This section should include more information about the components of the proposed agreements. The section adequately discusses access agreements for system monitoring by the MEW Companies. However, it should be explained whether and how these agreements may be relied upon to require building owners to operate HVAC systems as remedial systems. If the agreements will be the vehicle to require appropriate operation of an HVAC system, this section should explain (1) whether the agreements will serve as the assurance mechanisms that the HVAC systems are run appropriately to prevent exposure indoors above levels of concern; (2) whether the agreements will require monitoring and reporting by the building owner; and (3) whether there will be a reporting component to keep the PRPs and EPA apprised of changes in building ownership, management, tenancy, and building configuration, and HVAC system operations. Note that this list is not intended to be exhaustive; all components of the remedy that are expected to be addressed in these agreements should be explained in this section.

Response: Unrecorded covenants such as agreements between a land owner and the operator of a remedy are typically binding on private parties such as tenants through owner requirement regarding occupancy of the property. However, these agreements may not be binding on subsequent owners.

Agreements typically include provisions for 1) access to monitor and install a remedy, 2) notification in the case of change of ownership, and 3) notification in case of modification to the property that would affect the remedy. Agreements do not include how a remedy is to be operated. More specifically, the agreements do not require building owners to operate HVAC systems at certain levels.

There are several existing agreements in the MEW Area between the Companies and property owners that are broad enough to allow access, monitoring, and in some cases installation and operation of treatment systems. In addition, during the RI phase, the MEW Companies have been successful in obtaining additional agreements to monitor the indoor air quality and to install a mitigation measure when necessary.

In some cases, it may be necessary to modify agreements to include provisions regarding protection on indoor air quality (e.g., inspection of operation HVAC system, specifications on building modifications not to jeopardize vapor barriers or sub-slab pressurization or depressurization systems). However, it is not likely that the existing agreements will be modified, or the future agreements would be obtained, that would specify how an HVAC system is to operate. Instead, these specifications are established by state codes, zoning, and local permit requirements.

Many buildings in the Study Area operate HVAC systems with air exchange rates that are greater than 1/hr. During the RI/FS process, some buildings with lower exchange rates were identified, and the HVAC system was modified to allow for the additional makeup air. The MEW Companies will monitor operations of the HVAC systems, if such systems are used as a remedy for vapor intrusion. If monitoring indicates that the system is not operating at 1/hr exchange rate, then the building would either be sampled to confirm that indoor air concentrations are below the long-term cleanup level, or an alternative remedy would be proposed. If the owner does not provide access for either, the MEW Companies would refer the case to EPA.

In Section 9.4, the document references NASA's Environmental Issues Management Plan (EIMP) and associated required mitigation measures. These should be discussed more fully in this section for a full evaluation.

<u>Response:</u> This information will be included in the revised text.

<u>**Long Term Effectiveness and Permanence.**</u> **This section explains that existing agreements between the MEW Companies and property owners in the past have been reliable and effective. Discuss any concerns that may arise due to the expected expanded scope of the agreements. This section should elaborate on whether the existing agreements require building owners to perform any affirmative activities. Also, this section should explain whether the current owners have been apprised of the proposed remedy and what response they have provided to the MEW Companies regarding the remedy requirements.**

As discussed above regarding section 9.3.4, unrecorded agreements do not have the same permanence and level of effectiveness as recorded restrictive covenants. Because unrecorded agreements do not have these indicia of permanency, this section should describe the anticipated mechanism for entering into such agreements with future property owners.

This section discusses layering these agreements with other ICs, specifically with enforcement tools. As discussed in EPA's original comments on the ICs section and elaborated upon below, enforcement tools can be used as ICs, but they are generally only used to obligate PRPs to conduct activities or provide access. Otherwise, use of EPA's enforcement authority is limited to the rarest of circumstances when a property owner becomes a PRP by virtue of their non-cooperation with the remedy. Where the MEW Companies are having problems requiring the building owners to implement the remedy, EPA will look first to whether the MEW Companies have used their best efforts to obtain cooperation from the property owner prior to EPA using its enforcement authority.

<u>Response:</u> Existing agreements with property owners were used during the Supplemental RI/FS process to investigate the building layouts, collect indoor air samples, install a remedy when necessary, and operate and monitor the remedy. These agreements do not require building owners to perform affirmative activities since these requirements are not necessary. Should more intrusive remedies be necessary in the future, such as a sub-slab depressurization system, the MEW Companies will seek to revise the agreement, if needed, to ensure proper access, maintenance, and operation of the remedy.

The MEW Companies provided copies of the RI/FS to current owners of buildings that have been sampled during the RI/FS process. The FS includes proposed remedy requirements.

Other than agreements already recorded on properties previously occupied by MEW Companies, we do not anticipate that recorded agreements would be a likely scenario because the MEW Companies do not own properties in the MEW area.

<u>Implementability.</u> As discussed above, explain how these unrecorded agreements will be obtained from future landowners.

<u>Response:</u> See responses above.

<u>Cost.</u> There is no discussion of the cost to obtain and implement these covenants. Although amounts may not be easily estimated over the entire site, this section should discuss what costs may be involved to obtain agreements for both access and active remedy operation, particularly for those agreements that require operation of HVAC systems by the building owners.

<u>Response:</u> As mentioned in EPA's comment above, it is not easy to estimate this cost over the entire site, or for each property, given the many unknowns involved in access and covenant negotiations. To obtain such agreements, the MEW Companies would be negotiating with an unknown party, and therefore it is not possible to predict conditions imposed by the unknown third party to obtain an agreement. Cost scenarios will be provided in the revised FS.

Section 9.3.4 (now 8.3.4 in the revised FS) will be revised to include the information provided above.

<u>Specific Comment 6. Sections 9.3.5 and 9.3.6 Enforcement Tools: Administrative Orders and Consent Decrees</u>

As discussed in EPA's prior ICs comments, use of enforcement tools with non- PRPs should be very limited in the ICs context. Regardless of the ICs selected for this remedy, EPA maintains its access and enforcement rights. But EPA will expect the MEW Companies to implement the VI remedy and this section should explain how the MEW Companies intend to ensure that the selected remedial action is implemented and participation is achieved on an ongoing basis.

This section suggests that, should a property owner fail to cooperate with implementation of ICs, they can be ordered to record a restrictive covenant on their property requiring operation of the Site remedy. If it is anticipated that ongoing cooperation with an active remedy will be difficult to obtain from property owners, this issue must be discussed fully in the implementability analysis.

<u>Long-term Effectiveness and Permanence and Implementability:</u> These sections refer to EPA's resources, staffing, and potential administrative burden. These statements should be removed from both sections.

<u>Response:</u> An explanation of the IC processes and how they ensure that the remedial action is implemented and participation is achieved is provided in the response to General Comment 1. This explanation is best included after all ICs are evaluated, screened and selected. However, Section 9.3.5 and 9.3.6 (now 8.3.5 and 8.3.6 in the revised FS) will be revised to include reference to this explanation.

Per EPA's comment, the implementability section will be revised to add discussions regarding the possibility of owners not cooperating to operate and/or install a remedy.

Further, the "Long-term Effectiveness and Permanence and Implementability" section will be revised to delete the statements as directed in EPA's comment above.

Specific Comment 7. Section 9.3.7 Information Devices: Recorded Notices

This section raises the prospect of slander of title actions arising from the recording of informational notices on property and also that state law may limit the types of notices that may be recorded. Provide more information regarding potential slander actions and about California state limitations on such recording.

Response: The language regarding slander of title will be removed from Section 9.3.7 (now 8.3.7).

Specific Comment 8. Section 9.3.8 Information Devices: Public Notices

Informational devices can be effective tools to provide notice to a wide range of audiences. This section discusses making notices available at public agency offices or mailed to the property owners to provide a list of optional mitigation measures. However, public notices can be considered for a wider array of notice purposes. Notices can be provided to the general public, or be directed to certain groups, such as property owners, occupants, or prospective owners and occupants.

This section does not explain how notices will be directed and tracked. Additionally, there is no discussion of how notices can provide information back to the MEW Companies when there are new owners, occupants, or changed building conditions.

Long-Term Effectiveness. This section notes that public notices do not compel action by the recipient but may give them sufficient information to opt to take certain actions such as operate an HVAC during certain hours. It is unclear that how these notices on their own will be effective in influencing actions and expenditure of resources by building operators and how their effectiveness will be monitored.

Response: In reference to the destination of notices, the MEW Companies can provide notices to owners of properties overlying the study area. The Companies can also provide these notices to prospective owners. This will cover notice obligations for the vapor intrusion study area.

Providing notices to the general public beyond the study area would be outside the scope of this FS and outside the responsibilities of the MEW Companies.

Semiannual notices will be sent to property owners in the Vapor Intrusion Study Area. The list of owners and their contact information will be maintained. A title company will be used to update the list semiannually. The title company can also be used to provide an early indication of property transaction. Should notices be returned because of an incorrect address, the property owner will be contacted and the address updated.

Notices may contain a short questionnaire that can be filled by the property owner and mailed back to the MEW Companies. The questionnaire would include information requests on upcoming property transaction, changes in tenants, or planned modifications to building. Returned information requests will be filed and will be used to update the tenant and owner list that can be used for future notices. Information on building modifications would be used to evaluate whether the modifications affect the integrity of the remedy, and if they do, the property owner would be advised of the evaluation.

Regarding the comment on the effectiveness of the notices on their own, Chapter 9 mentions in the introduction under "Information Devices" that "they typically are not sufficient if used by themselves, and are used as an additional layer of control". Similar language will be added to the Long-Term Effectiveness section.

Section 9.3.7 (now 8.3.7 in the revised FS) will be revised according to the information above.

Specific Comment 9. Section 9.4 Selected ICs and Process

Layering of ICs or using ICs in series. ICs are more effective when used in series or layered. The series presented in this section, however, only provides one layer of ICs, with federal enforcement tools as a second layer. As discussed above regarding Sections 9.3.5 and 9.3.6, in this context enforcement tools can be used to require ICs, but they themselves are not the ICs. There should be further discussion of layering ICs, such as use of the CEQA process to require certain development details and agreements between the MEW Companies and building owners requiring operation of remedial equipment.

Response: Per EPA guidance, Section 9.4 structures the selected ICs in layers and series. The process and diagram in the section show four layers of ICs (zoning, local permits, covenants, and public notices) as the first series. Administrative Orders and Consent Decrees are the second series of ICs in case the first series (with four layers) are not successful. Also, please refer to response to General Comment 1. Further EPA guidance specify enforcement tools (Administrative Orders and Consent Decree) as one of four types of ICs.

No Further Action. No Further Action is a designation at a site where there is neither an engineered remedy nor ICs to be implemented. For this remedy, it is expected that there will be both an engineered remedy and ICs, thus the no further action designation is not appropriate. Additionally, where existing administrative or legal mechanisms are being relied upon for implementation and maintenance of a remedy, those mechanisms are still ICs. These measures can expire, be revoked, or remain unimplemented or not enforced, at which time the remedy would have to be reviewed. If the remedy is dependent upon such ICs for remedy implementation, the no further action designation is inappropriate.

Response: The "No Further Action" designation will be removed in the revised FS.

Semi-annual notices. This section should describe how the semi-annual notices to owners and tenants regarding the remedy will be implemented. For example, with notices only provided every six months, it is unclear how the notices will be directed to the appropriate persons following changes in building ownership or occupancy. Other methods to determine changes in building ownership should also be proposed.

Response: See response to Specific Comment 9. This section will be revised accordingly.

<u>**Specific Comment 10. Section 9.5: Monitoring of ICs**</u>

<u>Zoning.</u> Monitoring of zoning changes may be necessary where the Site remedy applies differently within different zoning designations. Annual review of these changes may not be sufficient to alert the MEW Companies in a timely manner to changes that require adaptation of the remedy's application. More frequent review of proposed zoning changes should be discussed here. Additionally, it should be clarified how the City provides notice of zoning change applications and whether there is, in fact, a mailing list maintained for this purpose. If there is no system for individual notice of such applications, other methods to review City files and report on such applications should be discussed.

<u>Response:</u> Annual review of zoning changes is adequate given the time required for such changes that require public notices, and City Council approval. Regardless, the revised FS will provide for semiannual review of zoning changes.

Current City of Mountain View notification practices is to notify owners within a 300-foot radius of the proposed zoning change. The City uses "Metroscan" to identify the property owners and their addresses. Metroscan is a database listing property owners and is provided by the County of Santa Clara.

<u>Covenants.</u> Along with periodic inspection of the status of covenants used as ICs, covenants should include self-monitoring provisions. Specifically, the covenants should include notification procedures should any of the agreements' underlying conditions change, such as building ownership, occupancy, or configuration. Periodic inspection is a good layered device to ensure that the self-monitoring is being implemented.

<u>Response:</u> The text will be modified to include an evaluation of the effectiveness of notification procedures. In addition to the notification provisions in agreements and periodic inspection of covenants and agreements, a title company will be retained to perform a semi-annual inspection of properties in the Study Area for upcoming transactions. Also, the internet site for the Santa Clara County Tax Collector website can be checked semiannually to monitor for recently completed transactions. These three layers of IC monitoring would serve as effective tools in monitoring effectiveness and performance of covenants and agreements.

<u>Public Notices</u>. This section does not appear to relate to monitoring of public notices, but rather offers examples of public notices themselves. Any monitoring of the public notice ICs should be discussed here.

<u>Response:</u> Please refer to response to Specific Comment 9. The text will be revised accordingly.

<u>Five-Year Reviews.</u> EPA conducts five-year reviews of site remedies while there is contamination remaining above levels that allow for unlimited use and unrestricted exposure. Although five-year reviews evaluate IC effectiveness, they are not IC monitoring systems unto themselves. In fact, a component of the five-year review process is to determine the effectiveness of the specifically designed IC monitoring mechanisms. The five-year review should be removed as an example of IC monitoring.

Response: The comment above contradicts with EPA Guidance (EPA 2003). EPA's 2003 "Guide to Implementing, Monitoring, and Enforcing Institutional Controls" specifies the Five-Year review as "an important opportunity for a [EPA] site manager to conduct an objective review of the status and performance of ICs".

APPENDIX C

SITE-SPECIFIC TCE INDOOR AIR LONG-TERM EXPOSURE GOALS FOR INDOOR WORKERS

Appendix C

Site-Specific TCE Goals for Indoor Workers
Final Supplemental Feasibility Study For Vapor Intrusion Pathway
Middlefield-Ellis-Whisman Study Area
Mountain View and Moffett Field, California

"Old" Equation (EPA RAGS Part A, 1989)

$$\text{Site-Specific Goal for Indoor Workers } (\mu g/m^3) = \frac{TR \times BW \times AT \times 1000\ \mu g/mg}{SF_i \times IR \times EF \times ED}$$

TR = cancer target risk, 10E-6 (unitless)
BW = body weight, 70 (kg)
AT = cancer averaging time, 25,550 (days)
SF_i = inhalation slope factor, 0.007 (per mg/kg-day) from Cal EPA
IR = indoor inhalation rate, 15 (m^3 per day)
EF = exposure frequency, 250 (days per year)
ED = exposure duration, 25 (years)

Substituting the above values into the equation,

"Old" Site-Specific Goal for Indoor Workers = 2.7 $\mu g/m^3$ TCE

"New" Equation (EPA RAGS Part F, 2009)

$$\text{Site-Specific Goal for Indoor Workers } (\mu g/m^3) = \frac{TR \times AT}{IUR \times ET \times EF \times ED}$$

TR = cancer target risk, 10E-6 (unitless)
AT = cancer averaging time, 25,550 (days)
IUR = inhalation unit risk, 0.000002 (per $\mu g/m^3$) from Cal EPA
ET = exposure time, 10 / 24 (hours per day)
EF = exposure frequency, 250 (days per year)
ED = exposure duration, 25 (years)

Substituting the above values into the equation,

"New" Site-Specific Goal for Indoor Workers = 4.9 $\mu g/m^3$ TCE

EPA RAGS Part F, 2009: Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), OSWER 9285.7-82, EPA-540-R-070-001, January.

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